6.0 CHARACTERIZATION OF LEAD HEALTH RISK 6-1
6.1 INTRODUCTION/METHODOLOGY 6-1
6.1.1 Lead Health Risk Assessment for the Resident Population 6-2
6.1.2 Lead Health Risk Assessment for the Coeur d'Alene Tribe 6-4
6.2 OBSERVED BLOOD LEAD LEVELS 6-5
6.2.1 Blood Lead Health Criteria 6-5
6.2.2 State of Idaho / Panhandle Health District Children's Blood Lead Survey Results 6-7
6.2.3 Summary Results for Follow-up Investigations of High Blood Lead Children 6-12
6.2.4 Adult Blood Lead Survey Results 6-15
6.3 LEAD EXPOSURE PATHWAYS 6-15
6.3.1 Dietary Lead Sources 6-16
6.3.2 Lead in Water 6-16
6.3.3 Lead in Air 6-16
6.3.4 Lead in Paint 6-17
6.3.5 Lead in Soils and Dusts 6-17
6.4 SITE-SPECIFIC BLOOD LEAD AND ENVIRONMENTAL EXPOSURE ANALYSIS 6-18
6.4.1 Correlation Analysis 6-18
6.4.2 Regression Analysis 6-19
6.4.3 Summary of Site-Specific Lead Health Analysis 6-22
6.5 BASELINE AND INCREMENTAL LEAD EXPOSURE INTAKE RATES 6-24
6.5.1 Exposure Routes Considered 6-24
6.5.2 Developing Baseline Intake Rates for the Resident Population 6-26
6.5.3 Developing Incremental Intake Rates for the Resident Population 6-29
6.5.4 Developing Intake Rates for the Coeur d'Alene Tribe 6-35
6.6 ESTIMATED BASELINE BLOOD LEAD LEVELS 6-36
6.6.1 Childhood Baseline Blood Lead Levels 6-36
6.6.2 Resident Children's Incremental Blood Lead Levels 6-40
6.6.3 Adult Model Blood Lead Estimates 6-43
6.6.4 Native American Blood Lead Levels 6-44
6.7 RISK CHARACTERIZATION 6-44
6.7.1 Overview and Summary 6-44
6.7.2 Indices of Lead Health Risk 6-45
6.7.3 Observed Blood Lead Levels 6-46
6.7.4 Site-specific Analysis of Paired Blood Lead and Environmental Source Observations 6-46
6.7.5 Predicted Blood Lead Levels 6-47
6.7.6 Potential Lead Health Risk Reduction Strategies 6-50

6.0 CHARACTERIZATION OF LEAD HEALTH RISK

6.1 INTRODUCTION/METHODOLOGY

The approach to human health risk assessment for lead differs from that of other metals in several ways. It is important to note those differences and how the methodologies employed relate to the Coeur d'Alene Basin population. Among the important considerations are the nature of the health effects, the behavior of lead in the body, measurements of biological effects, indices of risk, how risks are quantified, availability of data (both site-specific and in the national experience), and the relationships between absorption levels and environmental media.

The lead health effects of greatest concern, at the environmental and blood lead levels observed in the Basin, are subtle and sub-chronic in nature. That is, the adverse effects of low-level lead poisoning can result from relatively short-term exposures on the order of months, as opposed to periods of years to lifetime for other metals. Similarly the effects of lead poisoning are less likely to be diagnosed in a clinical setting and often go unnoticed.

Many of the adverse health effects of lead have been related to blood lead concentration or micrograms of lead per deciliter of whole blood (µg/dl). As a result, blood lead levels have evolved as indices of health criteria. Currently, 10 µg/dl has been identified as the level of concern for young children and pregnant women. The health effects observed at a blood lead level of 10 µg/dl are sub-clinical, meaning that, generally, these effects cannot be diagnosed in an individual child. Establishment of these sub-clinical health effects of lead was based on numerous scientific studies involving comparisons of large groups of children (NRC 1993, ATSDR 1999b, and CDC 1997).

Lead health risk assessment then evaluates potential for these adverse effects to occur by comparison of observed or predicted blood lead levels to these standards. Risks to population groups are assessed by determining the expected or observed percentage of the population to exceed those criteria. Risk to individuals is often expressed as the probability that the subject's blood lead level will exceed the specified level (i.e., 10 µg/dl).

Public health authorities have developed policies indicating the acceptability of certain probabilities or percentages of populations exhibiting blood lead levels in excess of the criteria. Those policies are presented in this Section. For example, the Department of Health and Human Services' current goal, with respect to children, is that 95% of all children in identifiable populations in the U.S. have blood lead levels less than 10 µg/dl.

As a result, lead health risk assessment involves either measuring or predicting blood lead levels for relatively short-term exposures and relating those to national criteria. For lead, special pharmaco-kinetic models have been developed to predict outcome blood lead levels resulting from different (lead) intake scenarios. These models have evolved to assist risk assessors in estimating population blood lead levels for differing environmental situations.

These models are especially useful in multiple source situations, such as the Basin, where individuals can be exposed to lead in many aspects of their lives. Coupled with site-specific measurements of blood lead levels and environmental exposure levels and the experience of the nearby BHSS, these models can be useful tools in aiding the understanding of the complex mechanisms involved in lead poisoning. The same findings can then be used to devise and implement response strategies to reduce risks and minimize the potential for lead absorption among the local population.

This type of analysis is performed in this Section for the resident population. Results from site-specific lead exposure studies, surveys of lead absorption and follow-up results for local children, and special environmental sampling have been combined with modern modeling efforts to provide a comprehensive analysis of lead health risks for the resident population in the Basin.

However, this approach was not possible with respect to the lead health risk concerns for the Coeur d'Alene Tribe. There are no site-specific human health biological data to evaluate. Tribal members abandoned traditional, historic subsistence practices in the River environment a century ago because of high levels of contamination. Currently available blood lead models were developed for suburban/urban applications and have not been tested nor applied to Native American traditional activities. As a result, risk assessment for potential subsistence activities by Tribal members is limited to estimating intake rates and qualitatively comparing those, to rates of other populations.

6.1.1 Lead Health Risk Assessment for the Resident Population

Two approaches to the lead Human Health Risk Assessment (HHRA) have been conducted to assist risk managers, the local communities, and public health officials in developing health protective strategies to minimize the future incidence of lead poisoning among the resident population in the Basin. These two methods are generally called ***conventional*** (e.g., a predictive, mechanistic approaches to blood lead modeling) and ***site-specific*** analysis (e.g., a descriptive, empirical approach). The traditional Integrated Exposure Uptake Bio-kinetic Model (IEUBK) approach is intended to be predictive of future, potential blood lead levels associated with a site. The site-specific approach more accurately describes past blood lead trends; its predictive value for future blood leads may be contingent on continuing public health intervention activities to monitor blood lead levels and reduce exposure. Both of these methods attempt to relate potential lead poisoning, as measured by blood lead content, to levels of lead in the environment.

In any assessment of human health risk in a community setting, basic steps are undertaken to characterize and evaluate the potential health problems. Those individuals and groups that are most sensitive, or most at-risk, to lead poisoning are identified. In this case, young children and women of reproductive age (as they might expose the unborn child) are the ***sensitive population***. The suspect ***sources of lead*** are identified. In the Basin, the principal sources are mining industry wastes and lead-based paint used on both the inside and outside of homes. Less prevalent sources include the historic use of leaded gasoline, plumbing, and other consumer goods that contain lead. Over the years, these sources have contaminated other ***environmental media*** that can now be contacted by children and women of reproductive age. In the Basin, ***soils and house dust*** are contaminated by historic discharges of mining industry waste, deteriorating paint, or past use of leaded gasoline. Soils may include home yards, roadsides and driveways, schoolyards, play grounds, recreational locations, the river floodplain, and other contaminated areas. ***Drinking water*** may be contaminated by mine wastes or use of lead solder in plumbing. Contaminated dust in the ***air*** can contribute to lead intake through inhalation. Soils and dust can also contaminate ***food*** from local gardens. Supermarket food may also contain lead.

Once these sources are known, the ***routes of exposure*** or pathways by which children or adults may contact and ingest this lead are identified. The routes of exposure of greatest concern in the Basin are children consuming soil and dust in their everyday activities, contaminated food, and drinking water. A variety of soil and dust media may be involved, and the lead in the soils and dust may come from different sources. Children consume interior dust in their homes, schools or day cares; and soils from home yards and play areas. Adults consume soil in both their home, and recreational and occupational environments. The lead in these soils and dusts can originate from paint, mine waste piles, tailings in the river floodplain, leaded gasoline combustion, deposition of airborne dust, and other potential sources. Lead exposure pathways are identified and media concentration data are summarized in Section 6.3.

In ***conventional risk assessment***, estimates are developed of how much lead is ingested (or taken into the body) through soils, dust, water, and food. This is accomplished by multiplying the amount of soil, dust, water, and food, etc., that children and adults consume, by the lead concentration in these media. This value is usually calculated in units of micrograms of lead ingested per day (μg/day) and is called the ***lead intake.*** The IEUBK Model for lead is used to estimate the average (i.e., geometric mean) ***blood lead level*** expected for a typical child consuming that amount of lead. However, all children do not respond in the same way to the same intake of lead; some have higher blood lead levels and others have lower. The IEUBK Model also predicts the percentage of children likely to exceed a given blood lead level. The exceedance predictions are calculated using an empirically derived measure of blood lead variability (i.e., geometric standard deviation) for a group of similarly exposed children. Intake rates are calculated and presented in Section 6.5. Blood lead estimates are developed in Section 6.6.

The United States Centers for Disease Control (CDC) determined that blood lead levels greater than 10 μg/dl present an undue risk of damaging health effects; the USEPA has established a national goal of no more than 5% of children in any community exceeding a 10 μg/dl blood lead level. The EPA guidance refers to both limiting exposure and determining soil lead concentrations so that "a typical (or hypothetical) child or group of children would have an estimated risk of no more than 5% of exceeding a blood lead of 10 μg/dl" (USEPA 1998f, USEPA 1994d). The IEUBK Model predicts that percentage of children (0-84 months) expected to exceed the ***10 ■g/dl blood lead health standard***. If the ***estimated risk of children having blood lead levels greater than or equal to 10 ■g/dl*** exceeds 5%, then corrective measures should be undertaken to reduce that risk. Lead health risks are characterized in Section 6.7.

Site-specific analysis of risk involves the collection of blood lead data from the resident population and ***relating the observed blood lead levels to measured concentrations in environmental media*** collected during the time of the study. These studies seek to establish that percentage of the population that is actually experiencing lead poisoning and characterize the direct link between lead in blood and the various media. This is generally accomplished by conducting well controlled investigations that collect both blood lead and environmental source data and relating those through statistical techniques.

In the site-specific approach, an actual measurement of the percent of children to exceed 10 μg/dl is obtained and relationships between blood lead and soil, dust, paint, water, and socioeconomic factors can be evaluated. This study design is cross-sectional, in that it is designed to describe relationships between environmental lead levels and levels of lead measured in blood at a particular point in time. These data can also be used to develop a hybrid risk assessment technique that uses the site-specific analysis to develop input parameters for the IEUBK Model that are particular to the Coeur d'Alene Basin. The latter approach was accomplished at the BHSS in 1990 and was used to develop the cleanup strategy employed there over the last decade. Existing blood lead data are summarized in Section 6.2 and site-specific quantitative analyses are presented in Section 6.4.

Both the conventional and site-specific approaches have been used at Superfund sites throughout the country and are consistent with USEPA guidance (USEPA 1989, 1994a). This risk assessment employs both methodologies. However, USEPA guidance requires that any site-specific analysis be based on compelling scientific evidence, collected in controlled investigations that are representative of the population of concern, the contaminated media, and the routes and pathways of lead exposure that are, or could be, occurring in the future.

6.1.2 Lead Health Risk Assessment for the Coeur d'Alene Tribe

For the purposes of this assessment, Coeur d'Alene Tribal authorities have requested that two specific tribal exposure scenarios be investigated, developed, and utilized within the Coeur d'Alene Basin (CDAB) Human Health Risk Assessment (HHRA). Those scenarios are the ***Traditional Tribal Subsistence Lifestyle,*** representing the aboriginal existence, and the ***Current Subsistence Lifestyle***, representing tribal members practicing modern subsistence activities. Both lifestyles were characterized in Section 3.1.3, and appropriate tribal exposure factors and consumption rates were developed. In large part, the various tribal exposure pathways and consumption rates included for use by the Coeur d'Alene Tribe were initially developed from research conducted with the Umatilla Tribe in Northeastern Oregon (Harris and Harper 1997). The results of that research were subsequently utilized within the Hanford Screening Assessment under a subsistence resident scenario (CRCIA 1996).

Research specific to the Coeur d'Alene Tribe has been conducted to evaluate the appropriateness of the Umatilla Tribal exposure factors in the HHRA. Adjusted exposure parameters extrapolated from the Hanford Screening Assessment are presented in Tables 3-26a-b. These exposure parameters are consistent with standard approaches to human health risk assessment, and are intended to protect traditional Coeur d'Alene Tribal riparian zone subsistence activities. The Traditional Tribal Subsistence exposure factors presented were developed assuming that the lifestyle involved residence within the floodplain for almost the entire year. The Coeur d'Alene Tribe has also requested that exposure factors and consumption rate information be developed and considered for current tribal members utilizing traditional hunting/gathering activities and a subsistence diet in today's environment (Current Subsistence Scenario). The Current Subsistence Scenario does not assume permanent residence within the floodplain.

Tribal exposure pathways are discussed in Sections 3.2.4 and 6.5.1. Lead intake for select pathways are developed in Section 6.5.4. Potential lead absorption is discussed in Section 6.6.4 and risks are discussed in Section 6.7.5.

6.2 OBSERVED BLOOD LEAD LEVELS

6.2.1 Blood Lead Health Criteria

Centers for Disease Control Advisory Regarding Children's Blood Lead Levels

The Centers for Disease Control have outlined three major areas for development of policies and activities related to childhood lead poisoning prevention. These areas are primary prevention activities, secondary prevention activities, and monitoring (surveillance). Primary prevention activities include evaluation and control of residential lead-based paint hazards, public lead education, professional lead education and training, anticipatory guidance by child health-care providers, and identification and control of sources of lead exposure other than lead-based paint. Primary prevention activities are aimed to prevent children from being exposed to lead (CDC 1997).

The Centers for Disease Control have the following secondary prevention guidelines regarding child blood lead levels (adapted from CDC 1997):

C	blood lead concentration <10 µg/dl	Reassess or rescreen in one year. No additional action is necessary unless exposure sources change.
C	blood lead concentration 10-14 µg/dl	Provide family lead education. Provide follow-up testing. Refer for social services, if necessary.
C	blood lead concentration 15-19 µg/dl	Provide family lead education. Provide follow-up testing. Refer for social services, if necessary. If blood lead levels persist or worsen (i.e., 2 venous blood lead levels in this range at least three months apart), proceed according to actions for blood lead concentrations in the 20-44 µg/dl range.
C	blood lead concentration 20-44 µg/dl	Provide coordination of care (case management), clinical management, environmental investigation, and lead- hazard control.
C	blood lead concentration 45-69 µg/dl	Within 48 hours, begin coordination of care (case management), clinical management, environmental investigation, and lead- hazard control.

C blood lead concentration ≥70 µg/dl — Hospitalize child and begin medical treatment immediately. Begin coordination of care (case management), clinical management, environmental investigation, and lead-hazard control immediately.

U.S. Environmental Protection Agency Policy regarding Children's Blood Lead Levels

At lead contaminated residential sites, EPA seeks assurance that the health of the most susceptible population (children and women of child bearing age) is protected and promotes a program that pro-actively assesses and prevents unacceptable exposures to lead. EPA believes that predictive tools should be used to evaluate the risk of lead exposure, and that cleanup actions should be designed to address both current and potential future risk. For this reason, cleanup decisions can be made on IEUBK predicted blood lead levels alone. Blood lead monitoring provides useful and complementary data to Model results. Blood lead monitoring data is invaluable to initiate treatment and intervention for children with elevated lead levels, but of limited use in developing remedial action criteria.

To meet these objectives, EPA seeks actions that limit exposure to soil lead levels such that a typical child or group of similarly exposed children would have an estimated risk of no more than 5% exceeding a 10 upper confidence limit blood lead level.

EPA emphasizes the use of the IEUBK Model for estimating risks for childhood lead exposure from a number of media, such as soils, dust, air, water, and other sources to predict blood lead levels in children 6 months through 84 months old. EPA recommends that the IEUBK Model be used as the primary tool to generate risk-based soil cleanup levels at lead sites for current or future residential land use. Response actions can be taken using IEUBK Model predictions alone; blood lead studies are not required.

Blood lead studies and surveys are useful tools at lead sites and can be used to identify key site-specific exposure pathways and to direct health professionals to individuals needing immediate assistance in minimizing lead exposure; however, EPA recommends that blood lead studies not be used for establishing long-term remedial or non-time-critical removal cleanup levels at lead sites.

It is recommended that risk assessments conducted at lead-contaminated residential sites use the individual residence as the primary exposure unit of concern. This does not mean that a risk assessment should be conducted for every yard, rather that the soil lead concentration data from yards and other residential media (for example, interior dust and drinking water) should be input into the IEUBK Model to provide a preliminary remediation goal (PRG) for the residential setting. When applicable, potential exposure to accessible site-related lead sources outside the residential setting should also be evaluated to understand how these other potential exposures contribute to the overall risk to children, and to suggest appropriate cleanup measures for those areas (USEPA 1998f).

Bunker Hill Superfund Site Remedial Action Objectives

Site wide Remedial Action Objectives (RAOs) are defined in the Populated and Non-populated Records of Decision (RODs) for the Bunker Hill Superfund Site (BHSS) (USEPA 1991c, USEPA 1992b). The blood lead RAOs were defined in the 1991 Populated Areas ROD and were based on site-specific blood lead levels among children and environmental media lead concentrations at the site; the RAOs defined for the BHSS were developed prior to publication of the 1994 EPA guidance that outlines the current blood lead criteria (USEPA 1994d). The blood lead RAOs at the BHSS seek to reduce the incidence of lead poisoning in the community to the following levels:

C less than 5% of children with blood lead levels of 10 µg/dl or greater, and

C no individual child exceeding 15 µg/dl (nominally, <1% of the population).

These objectives are to be achieved by a strategy that includes:

i) Remediating all residential yards, commercial properties, and Rights-of-way (ROWs) that have lead concentrations greater than 1000 milligrams of lead per kilogram of soil (mg/kg);

ii) Achieving a geometric mean yard soil concentration of less than 350 mg/kg for each community in the site;

iii) Controlling fugitive dust and stabilizing and covering contaminated soils throughout the site; and

iv) Achieving geometric mean interior house dust lead concentrations for each community of 500 mg/kg or less.

The success of the BHSS strategy depends on reduction of interior house dust lead levels to concentrations comparable to post-remedial area soils. If house dust lead levels remain elevated, within the BHSS, homes with concentrations greater than 1000 mg/kg will be considered for interior remediation.

6.2.2 State of Idaho / Panhandle Health District Children's Blood Lead Survey Results

Sources of Site-specific Blood Lead Observations

Surveys of blood lead levels in the Basin have been conducted in each of the last four summers from 1996 to 1999. The initial survey was conducted in association with the *Coeur d'Alene River Basin Environmental Health Exposure Assessment* (IDHW 1999). Participants in the 1996 study were solicited at their homes for both blood lead samples and an environmental survey of the residence. Most of those families contacted, consented to the environmental survey and samples were collected from 843 homes. A total of 667 adults and 98 children aged 9 months through 9 years provided blood lead samples. These data were analyzed and discussed in the parent document (IDHW 1999).

Subsequent fixed-site blood lead screening was offered in both 1997 and 1998. In 1997, 26 children aged 9 months through 9 years responded. Eleven of these children had provided samples in the previous year. In 1998, parents of 128 children opted to participate in the program. Despite the increased turnout, the relatively small number of participants caused concern among public health authorities that the results may not be representative of the Basin wide population. A more aggressive solicitation was accomplished in 1999. Government and mining industry officials agreed to jointly support a fixed-site screening and each participant was offered $40 to provide a blood sample. Turnout was considerably larger as a result of the increased solicitation efforts and incentives. A total of 272 children in the target age group provided samples in 1999. This represents approximately 24% to 27% of the estimated 1025 to 1120 children in the Basin study area.

Blood lead summary data for children 9 months through 9 years old, by year and geographic subareas, and the numbers of children targeted for follow-up health response services are presented in Tables 6-1 and 6-2. Figures 6-1a-b show mean blood lead levels and the percent of children to exceed the 10 µg/dl and 15 µg/dl health criteria by geographic area for both the Basin and the BHSS.

Site-specific Blood Lead Results for Children

Table 6-1 shows Basin wide summary results for each of the four surveys. The overall geometric mean blood lead level for the 1997 to 1999 surveys was 4.2 µg/dl compared to 4.0 µg/dl in the 1996 survey, indicating consistency in the overall level of absorption in recent years. The percentage of children with levels greater than or equal to 10 µg/dl ranged from 9% to 15%, or 10% for the four year period. About 5% of children have had levels 15 µg/dl or greater and between 1% and 2% of children exhibited blood lead concentrations greater than 20 µg/dl. These latter results also seemed consistent across the four year period despite the variation in turnout.

Follow-up services include counseling by a public health nurse and an environmental exposure assessment of the child's residence. Of the 58 children exhibiting blood lead levels greater than 10 µg/dl, 50 follow-up investigations were successfully completed and the findings are summarized in Section 6.2.3.

Blood Lead Levels and Percent to Exceed Toxicity Criteria by Geographic Subarea

Mean blood lead levels and the percent of children to exceed 10 µg/dl differ by Basin subarea. Mean blood lead levels and the number and percentage to exceed toxicity criteria for subareas are shown in Tables 6-2 and 6-3. The highest levels are observed in the upper Silver Valley or easternmost portions of the of the study area. Arithmetic mean concentrations for the four year period are 7.4 µg/dl, 6.0 µg/dl and 5.2 µg/dl for Burke/Nine Mile, Wallace and Mullan, respectively. Arithmetic mean levels range from 4.1 µg/dl to 4.9 µg/dl in the intermediate areas from Silverton downstream to Kingston. The arithmetic mean concentration for the Lower Basin/Cataldo subarea is 5.5 µg/dl. Geometric mean blood lead levels follow a similar pattern.

The percent of children to exceed toxicity criteria shown in Table 6-3 also follows a similar pattern. The highest toxicity rates are observed in Burke/Nine Mile at 21% exceeding 10 µg/dl, 13% exceeding 15 µg/dl and 4% with levels of 20 µg/dl or greater. The Lower Basin/Cataldo subarea showed the next highest toxicity rate with 18% exceeding 10 µg/dl and 5% greater than the 15 µg/dl criteria. No children were in the 20 µg/dl range in the Lower Basin. Wallace, Mullan and Silverton, respectively, showed 13%, 11% and 8% of children with levels of 10 µg/dl, or greater. From 4% to 5% of children tested in Silverton and Wallace exhibited blood lead levels exceeding the 15 µg/dl criteria and 1% in Silverton and 3% in Wallace exceeded 20 µg/dl. Osburn and the Side Gulches area both showed 4% of children exceeding 10 µg/dl and only one child in all four years exceeded 15 µg/dl in the Side Gulches. Kingston showed 11% greater than or equal to 10 µg/dl and 7% exceeded the 15 µg/dl criteria.

Blood Lead Levels and Percent to Exceed Toxicity Criteria by Age Group

Tables 6-4a-c and 6-5 and Figure 6-2 show the blood lead distribution by age for all children for all years. The highest blood lead levels are observed in the youngest age groups as shown in Tables 6-4a-c. One and two year old children have arithmetic mean blood lead levels of 7.0 µg/dl and 8.0 µg/dl , respectively, and geometric mean concentrations of 6.2 µg/dl to 6.3 µg/dl. Geometric mean levels then decrease with age from 5.2 µg/dl at age 3 to 3.0 µg/dl at age 8. There is a slight increase in mean concentrations for 9 year olds.

The percent of children to exceed critical toxicity levels differs markedly with age, as shown in Tables 6-4a-c and Figure 6-3. In the lowest age groups, 9 months to 3 years, 19% to 26% exceed the 10 µg/dl criteria. The rate is highest in 2 year old children with 17% of this group equal to or exceeding 15 µg/dl. For 4 year old children 12% exceed the 10 µg/dl criteria and 5% exceed 15 µg/dl. In older children the percent to exceed 10 µg/dl ranges from 5% to 8%, and 1% to 3% greater than or equal to 15 µg/dl.

Age-adjusted Blood Lead and Toxicity Estimates

It is important to note the relative rate of participation for children among the different age groups. Fewer children participated in the youngest age groups. Forty and 46 individuals in the 1 and 2 year old categories, respectively, provided samples over the last 4 years, as opposed to 72 and 91 children, respectively in the oldest age groups. As a result, overall statistics provided for these results are possibly biased toward higher age groups and lower blood lead levels and incidence of toxicity. Tables 6-6a-b show observed and estimated mean blood lead levels for 1-6 and 1-7 year old children for each Basin subarea, respectively. The age-adjusted percent to exceed the 10 µg/dl criteria for these populations is 16.2% for 1-6 year old children and 14.8% for 1-7 year old children, as shown in Tables 6-4b-c.

Comparison to National and State wide Lead Absorption Databases

Comparison of blood lead data for the Coeur d'Alene Basin to other sites and national or State wide surveys is problematic. There is a divergence of opinions regarding the appropriate comparisons. In previous memoranda, the State has offered the following description of blood lead levels observed within the BHSS relative to State and national surveys (edited to reflect Basin blood lead levels):

> Basin wide, 10% of 9 month through 9 year old children tested in 1999 showed blood lead levels of 10 µg/dl or greater and 5% exceeded 15 µg/dl. In the Superfund Site, 6.2% of children tested in 1999 showed blood lead levels of 10 µg/dl or greater and 0.8% exceeded 15 µg/dl. For 1-6 year old children in the Basin, the percent to exceed 10 µg/dl was 16%, and 8% exceeded in the Superfund Site in 1999. These results can be compared with a State wide survey conducted in 1997 that found pre-school children living in pre-1970 housing exhibited 4.2% exceedance of the 10 µg/dl criteria (IDHW 1998). Nationally, the 1991-1994 National Health and Nutrition Evaluation Survey (NHANES III) reports that 5.6% and 1.4% of 1-5 year old children in pre-1946 and 1946-1973 aged housing, respectively, exceed the 10 µg/dl blood lead criteria among similarly aged white non-Hispanic children (Pirkle et al. 1998).
>
> The 1999 Basin wide geometric mean blood lead level for 9-month to 9-year old children was 4.2 µg/dl and ranged from 3.3 µg/dl in Osburn to 5.6 µg/dl in Burke/Nine Mile. In the Superfund Site, the 1999 geometric mean blood lead was 3.9 µg/dl, down from 4.0 µg/dl in 1998 and 4.5 µg/dl in 1997. As summarized in Table 6-7, for 1-6 year old children, the mean Basin wide blood lead level was 5.2 µg/dl compared to 4.2 µg/dl in the Superfund Site. State wide, the mean blood lead level for 1-6 year old children was 3.7 µg/dl in older housing. The majority of housing in the Basin is in the pre-1970 category. Nationally, comparable levels in 1991-1994 were 3.3 µg/dl and 2.4 µg/dl in pre- and post-1946 housing, respectively (Pirkle et al. 1998).

Comparisons of these results with elevated blood lead prevalence rates from Idaho wide or nation wide surveys is problematic and should be done with caution. Such large data sets, for various technical reasons, cannot be used to compare and draw conclusions about the relative degree of health hazard existing for children in the Basin communities.

Scientific designs of the NHANES surveys, are constructed in a way that does not allow simple comparisons with results of blood lead distributions for a single community. NHANES data provide a current snapshot for numerous *national* subsets or strata, that may not be appropriate for any single community. An explicit warning on technical grounds against making such comparison is in the Executive Summary of ATSDR's 1988 report to Congress on childhood lead poisoning in America (ATSDR 1988).

Additionally, the purpose and design of the Basin surveys were conducted in a manner that does not match the organization of the various demographic and socioeconomic strata in the NHANES III survey reports (e.g., race/ethnicity, income, housing age).

Table 6-7 shows comparisons of blood lead levels from the various studies.

6.2.3 Summary Results for Follow-up Investigations of High Blood Lead Children

Follow-up Services

Follow-up investigations were conducted for 50 of the 58 children exhibiting high blood lead levels in the Basin. Follow-up lead health counseling consists of a public health nurse and/or a senior environmental health specialist employed by PHD contacting the parents of each child with an elevated blood lead level. The health specialist and nurse provide counseling and written information on how to identify sources of lead and reduce the child's exposure. A questionnaire is completed and educational materials are provided to the parents of children with a blood lead equal to or greater than intervention levels. Nutritional counseling and multiple vitamins with iron are also provided. A follow-up blood screen is offered 3-4 months later, and it is recommended that the child's blood lead information be shared with the family physician and that the child participate in the following Summer Screening Programs.

The environmental survey includes:

- A records search of environmental data collected from the residence.
- Sampling of soil, dust, paint, water, etc., as appropriate.
- Counseling regarding the avoidance of locally grown produce.
- Education regarding play activities, including those not associated with the primary residence.
- Evaluation of sources of exposure associated with parental occupations, hobbies, and other household activities.
- Evaluation of past or planned home remodeling activities.
- Recommendation for those without vacuum cleaners to use one of the high efficiency vacuums available through the Lead Health Intervention Program (LHIP).

A public health nurse and a senior environmental health specialist are available for consultations regarding sources of exposure to lead and the management of exposure pathways. A variety of locally developed and commercial fact sheets, brochures, coloring books, and videos are available regarding lead and children and exposure to lead during pregnancy.

Lead health information has been integrated into existing programs offered by the local health district. This information has been added to the Well Child Program, Immunization Clinics, Woman Infant and Children (WIC) Clinics, and pregnancy screening and prenatal clinics offered by the PHD. Prenatal blood lead screening is available for all pregnant women in the area through the LHIP. Pregnant women are offered blood lead testing and nutritional counseling during the first and third trimesters and are advised to provide their blood lead and exposure history to their private physicians. It is also recommended that a cord blood sample be collected when the child is born.

Each year, a public health nurse visits area grade schools. Classes are conducted for students in kindergarten through the third grade, and the nurse is available for presentations to classes through the 12th grade. Various methods are used including a puppet show and doll house to teach the concepts. The presentation covers the students' role in identification and management of exposure pathways that may affect them or their siblings. The program is presented in May so children can be reminded of the hazards of lead in soil and dust prior to summer vacation, when they are at the greatest risk of exposure.

A physician awareness program has been developed to keep local physicians apprized of program activities and the services that are available. Reference materials and a resource manual regarding lead and other heavy metals have been provided to area physicians and the local hospital. Upon request, additional follow-up activities and sampling can be conducted on behalf of physicians with special concerns regarding a patient with an elevated blood lead level.

Follow-up Results

A total of 25 follow-up investigations over the last four years were for children with blood lead levels greater than 15 µg/dl. These investigations concerned 21 individual children in 19 families. A small number of children were followed for more than one year. Children who were provided with follow-up services ranged in age from 1 to 9 years. One child was 1 year old, 6 children were aged 2 years, 3 children of age 3, 4 aged 4 years old, 3 were 5 years old, 1 aged 7, 1 child 8 years old, and 2 children were aged 9 years. Several siblings of these children also had blood lead levels in the 10-14 µg/dl range.

Eleven children, or more than 50% of those with blood lead levels above the 15 µg/dl standard, were from Burke/Nine Mile or Wallace. Three of these children were from Silverton and the Side Gulches, and 7 were from Kingston, Cataldo and the Lower Basin. No children with blood lead levels exceeding 15 µg/dl were from Mullan or Osburn.

Of the 8 children from Burke/Nine Mile, 3 were two years old and the remainder were 4 to 9 years old. These children's exposure profiles were characterized by high soil and dust concentrations, generally exceeding 2000 mg/kg; access to contaminated tailings in local play areas; and one home with possible paint problems.

In Wallace, 4 children, all less than or equal to 4 years of age, exhibited blood lead levels exceeding the 15 µg/dl criteria. Each child's exposure profile indicated possible paint or remodeling difficulties, the homes were noted as dusty and difficult to keep clean, and contaminated play areas were indicated for some children. Investigations of the 3 children in the Silverton/Side Gulches areas indicated possible play area exposures and potential difficulties with former residences in other subareas of the Basin.

There were 7 children with blood lead levels greater than 15 µg/dl in the Kingston and Lower Basin areas. There were 2 two year olds, 2 three year olds, and 2 five year olds and 1 four year old children. All of the children's profiles either indicated extremely high soil and dust lead levels (> 4000 mg/kg) associated with flooding, or extended time in contaminated recreational areas in the Lower Basin.

The remaining follow-up investigations were conducted on children in the 10-14 µg/dl blood lead range. Many of these children were siblings of those discussed above. Of 6 additional follow-up surveys completed in the Kingston/Cataldo/Lower Basin subareas, most were in Cataldo and involved homes contaminated by flooding or older children recreating in the river or lateral lake areas.

Seven additional follow-up investigations were conducted in the Osburn, Side Gulches, and Silverton subareas. These children were from seven different age groups. No paint or remodel problems were indicated. One child lived in a home with soil and driveway lead levels exceeding 2000-3000 mg/kg, and 4 children were noted to play in contaminated recreation areas.

Of 5 additional children followed in Wallace in the 10-14 µg/dl category, 2 children were 1 year old, 1 child was 2 years old, 3 were 3 years old, and 2 children were 4 years old. Three children's risk profiles indicated possible paint or remodeling problems, and one child spent extended time in a Lower Basin campground with high soil and sediment lead levels.

Five additional children were followed in the Burke/Nine Mile area. One child was 2 years old, 1 was 3 years old, 1 was 5 years old, 1 was 6 years old, and the remaining child was 7 years of age. These children's profiles indicated high soil and dust concentrations and exposure to tailings during recreational activities. Two children, ages 4 and 8 years, were followed in Mullan. High soil and dust concentrations and playing in mine waste areas were indicated in the risk profiles.

Summary of Follow-up Findings

In summary, the follow-up risk profiles indicate excess absorption associated with high soil and dust concentrations at homes in the Burke/Nine Mile subarea. Older children's risk profiles in this area indicate recreational exposures in neighborhood areas contaminated by tailings and old mill sites. High blood lead levels in Wallace are indicated in younger children and are possibly associated with paint and remodeling problems, high soil lead levels in play areas, and dusty or difficult to clean homes. Both Mullan and Osburn had no children in the greater than 15 µg/dl blood lead criteria and children's blood lead levels in the 10-14 µg/dl range were associated with high residential soil and dust concentrations or play in contaminated areas. West of the BHSS, excess absorption was associated with either homes that had been flooded or with extended recreational activities in the river or lateral lake areas.

6.2.4 Adult Blood Lead Survey Results

Adult Blood Lead Levels by Age and Subarea

Table 6-8a summarizes adult blood lead levels collected in the 1996 Basin wide survey by geographic subarea. Figure 6-4 shows geometric mean blood lead levels by area and age group for the entire adult population. Figure 6-5 shows geometric mean and maximum blood lead levels for reproductive aged females (17-45 years) by geographic subarea. For the overall population, mean blood lead levels increase with age. Residents older than 50 years show mean blood lead levels ranging from 30% to 90% higher than the 10-25 year old category. Mean blood lead levels in the younger group range from 1.9 µg/dl in Silverton to 3.2 µg/dl in the Burke/Nine Mile area. Generally, adult blood lead levels show a pattern similar to children with the highest levels occurring in the areas east of Wallace and lower levels in Osburn and the Lower Basin. Exceedance of the 10 µg/dl health criteria was uncommon among younger individuals with the majority of high levels occurring in older individuals in the upper Basin. The highest exceedance rate was in the Burke/Nine Mile area with 7 of 66 adults tested showing levels of 10 µg/dl or greater.

Blood Lead Levels for Reproductive Aged Females

Table 6-8b and Figure 6-5 summarize results for reproductive aged females. Among reproductive aged women, 2 of 151 women tested in the 17 to 45 year age group showed levels greater than or equal to 10 µg/dl. The highest level observed was 16 µg/dl. Geometric mean blood lead levels among reproductive aged females were 2.0 µg/dl or less in all areas except Burke/Nine Mile (2.4 µg/dl) and Wallace (2.6 µg/dl). The USEPA has recommended using a baseline blood lead estimate of 1.7 µg/dl to characterize non-Hispanic, white, rural adult female populations in the United States. Blood lead levels among reproductive aged individuals in the Basin are slightly higher, with some increase noted in the Wallace and Burke/Nine Mile subareas.

6.2.5 Coeur d’Alene Tribe Blood Lead Levels

No observed blood lead data are available for Coeur d’Alene Tribe members other than those included in the resident population. No measurements of biological response to lead exposure are available for Tribal members that engage in subsistence lifestyles.

6.3 LEAD EXPOSURE PATHWAYS

Children and adults are exposed to lead from a variety of sources in their everyday environment. Figure 6-6 shows the model evaluated in formulating the clean-up strategy and in subsequent IEUBK Model analyses of blood lead response for the BHSS. This model suggests that children are exposed to multiple contaminated environmental media including diet, drinking water, air, soils and dusts, and other consumer products including lead paint in the home.

6.3.1 Dietary Lead Sources

Market Basket Foods

Table 6-9 summarizes national Market Basket lead intake rates used for the resident population in this risk assessment. These values are obtained from the IEUBK Model for lead (USEPA 1994b).

Local Produce/Riparian Zone Produce/Fish

Table 6-10 summarizes media concentration data for garden produce (collected by URS Greiner in 1998 under FSPA 06), riparian vegetation (collected by the Coeur d'Alene Tribe in 1994), fish fillets from the lateral lakes (collected by State of Idaho from 1995-1997) and whole fish (collected by Washington State Department of Ecology) from the Spokane River.

The fish ingestion pathway evaluation for the tribal scenarios is based on filleted tissue metals data from a limited number of species from the lateral lakes and whole fish from the Spokane River. These results are likely not representative of fish from Lake Coeur d'Alene and extrapolation of hazards and risks to the Lake Coeur d'Alene fishery is not recommended.

6.3.2 Lead in Water

Drinking Water Sources

Tables 6-11a-j include both first draw and purged drinking water system lead results for the resident population. For the lead analysis, the purged lead concentration for tap water was used.

Surface Water Sources

Tables 6-12a-b summarize surface water lead levels for both disturbed and undisturbed samples, respectively.

6.3.3 Lead in Air

Lead in air data are not available for the Basin. However (for the purposes of this report), lead in air is assumed to be a minimal contributor to overall exposure and IEUBK Model default assumptions are applied when applicable. See Section 3.2.2.

6.3.4 Lead in Paint

Paint lead was measured in the upper Basin in the large epidemiologic surveys conducted in 1974-75. The highest levels of lead paint in those surveys were noted in the communities east of Wallace (IDHW 1976). Because the housing stock is predominantly older than 1960, lead paint is prevalent and has been investigated on a case-by-case basis in the follow-up of children with high lead levels. Occasional problems with lead paint have been noted in individual situations, but health officials do not believe this problem to be widespread. The majority of interior paint lead impact is believed to be manifested through house dust.

Lead in paint was measured by XRF techniques in the *Coeur d'Alene River Basin Environmental Health Exposure Assessment* (IDHW 1999). Those data were analyzed in a semi-quantitative manner in the cited report. Those data have since been reanalyzed for the purposes of this risk assessment. XRF results were compiled on a house-by-house basis from the 1996 survey. All XRF readings and appropriate notations and surface condition variables were entered into a computer database. These results were then summarized to determine minimum, maximum, median and mean concentration and condition results for interior, exterior and entryway surfaces. Table 6-13 shows summary statistics for lead-based paint by geographic subarea. Figures 6-7a-b show mean interior and exterior paint lead concentrations by geographic area.

6.3.5 Lead in Soils and Dusts

The soils and dust pathways are among the most complex and, generally, greatest contributors to childhood lead levels. Available soil and dust data suggest that house dust contains a complex combination of lead from several sources moderated by environmental conditions and social, economic, and cultural factors that influence maintenance and behavior. Soils from home yards, neighborhoods, and throughout a community all seem to contribute significantly to house dust (TerraGraphics 2000a). Excepting children that eat paint chips, lead paint exposure predominantly comes from peeling and chalking paints incorporated into house dusts or outdoor soils. Local produce is most often contaminated by soils or dusts adhering to plant tissue despite washing efforts. Airborne contamination presents its greatest hazard as it settles and contaminates surface dusts that are ingested by children.

These factors suggest that children are exposed by both direct contact with contaminated soils or house dusts and indirect exposure to contaminated soils through house dusts which originate from outdoor soils, paint, and possibly, residual dust particulate in structures (TerraGraphics 2000a, Succop et al. 1998).

Yard Soil Lead Levels

Yard soil, play area, garden, driveway and rights-of-way (ROW) soil lead levels are summarized by geographic area in Tables 6-11a-j. These tables also contain percentage distributions for relative contaminant levels by subarea. Figures 6-8a-c show mean yard soil and house dust lead levels for the Basin and other areas in North Idaho.

Community and Neighborhood Soil and Sediment Lead Levels

Table 6-14 summarizes neighborhood stream sediment lead concentration by geographic subarea.

Common Use Area Soil and Sediment Lead Levels

Tables 6-15a-b summarize soil and sediment lead levels, respectively, for common use areas by geographic subarea.

Waste Piles

Table 6-16 summarizes available lead contamination levels for waste piles.

House Dust Lead Levels

House dust lead levels for vacuum bag and dust mat samples collected in the Basin are summarized by geographic subarea in Tables 6-11a-j and Figures 6-8a-b. Dust and lead loading rate data from 1996 entryway mats are summarized in Table 6-17 and Figures 6-9a-c.

Riparian Zone Soil and Sediment Lead Levels

Table 6-18 summarizes soil and sediment lead concentration levels in the Lower Basin floodplain from Rose Lake to Harrison.

6.4 SITE-SPECIFIC BLOOD LEAD AND ENVIRONMENTAL EXPOSURE ANALYSIS

6.4.1 Correlation Analysis

Blood and Environmental Lead Level Correlations

General correlation matrices were developed for the blood and dust database for all geographic areas combined. These matrices were examined to assess the linear association between the pairs of variables and to preliminarily identify the best predictors of blood lead levels and house dust lead concentrations for multiple regression model analysis. Tables 6-19 and 6-20 show the overall correlation matrix for all geographic areas for blood and dust lead levels. Most of the correlations in Tables 6-19 and 6-20 are highly significant (p#0.001).

Examination of the correlation matrix for blood lead levels (Table 6-19) shows that blood lead level is significantly correlated with age, dust mat lead, yard soils, community geometric mean soils, and paint lead levels. The highest correlations are with the lead loading rate (r=0.63, p#0.001), followed by the mean interior paint condition (r=0.48, p#0.001). Other high correlations with blood lead levels are the median exterior lead XRF reading (r=0.41, p#0.001), the median exterior paint condition (r=0.40, p#0.001), the median interior lead XRF reading (r=0.34, p#0.001), mat lead concentration (r=0.31, p#0.001), yard soil lead (r=0.16, p#0.001), and the community geometric mean soils (r=0.12, p#0.05). Scatterplots for select variable pairs are presented in Figure 6-10a.

The correlation matrix for the house dust mat data (Table 6-20) shows that log transformed dust mat lead concentration is significantly correlated with yard soils, community geometric mean soils, and paint lead levels. The highest correlations are with the log transformed yard soil lead (r=0.65, p#0.001), followed by the community geometric mean soils (r=0.56, p#0.001) and non-log-transformed paint variables; the maximum interior lead XRF reading (r=0.30, p#0.001), the arithmetic mean exterior lead XRF reading (r=0.29, p#0.001), and the maximum interior paint condition (r=0.13, p#0.05). Scatterplots for select variable pairs are presented in Figure 6-10b.

The house dust mat data, (Table 6-20) shows that log transformed lead loading rate is significantly correlated with yard soils, community geometric mean soils, and paint lead levels. The highest correlations are with the log transformed yard soil lead (r=0.53, p#0.001), followed by the community geometric mean soils (r=0.44, p#0.001) and non-log-transformed paint variables; the maximum interior lead XRF reading (r=0.29, p#0.001), the arithmetic mean exterior lead XRF reading (r=0.26, p#0.001), the mean interior paint condition (r=0.25, p#0.001), and the mean exterior paint condition (r=0.25, p#0.001). Scatterplots for select variable pairs are presented in Figure 6-10c.

Examination of the correlation matrix for the house dust vacuum data (Table 6-20) shows that log transformed vacuum cleaner bag lead concentration is significantly correlated with dust mat lead content, yard soils, community geometric mean soils, and paint lead levels. The highest correlations are with the log transformed dust mat lead concentration (r=0.72, p#0.001), followed by the log transformed yard soil lead (r=0.52, p#0.001), the community geometric mean soils (r=0.45, p#0.001) and non-log-transformed paint variables, the maximum interior lead XRF reading (r=0.30, p#0.05), and the arithmetic mean exterior lead XRF reading (r=0.25, p#0.05). Scatterplots for select variable pairs are presented in Figure 6-10d.

6.4.2 Regression Analysis

Blood Lead and Environmental Exposure Factors

Stepwise regression analysis was employed to identify variables for the best model describing the blood lead and environmental exposure relationship. The single variable model step identified lead loading rate on entryway mats as describing most of the variation in blood lead levels. Yard soil lead concentrations were identified as the next most significant variable. These variables were followed by the median exterior paint concentration, as measured by XRF, and the minimum interior paint condition. No other variables met significance criteria of p=0.05 in the presence of these factors.

Although the residuals of this model are normally distributed and basic statistical assumptions are met, variables included in the model are distributed log-normally. This model form was also investigated using log transformations for both independent and dependent concentration variables and alternate statistics (mean, maximum, minimum, median) for the paint related measurements. No improvements in model significance, R-square statistic or residual distributions, were noted with variable transforms. The R-square statistic was diminished with the dependent variable transform. No other paint variables were found to increase model significance or the R-square value. Interior paint concentration and exterior condition were not significant in any measurement.

Table 6-21 shows the best model selected to describe blood lead levels. Five variables are included that explain about 60% of the variation in children's blood lead levels. This is a strong relationship for a study of this type. In previous analysis of blood lead and environmental exposures in the Basin (including the BHSS) typical R-square statistics ranged from 0.20 to 0.75 with the lower range more common in recent years (TerraGraphics 2000a, Yankel et al. 1977). The variables selected include: i) Age of the Child, ii) Yard Soil Lead Level, iii) Dust Mat Lead Loading Rate, iv) Median Exterior Paint Lead Concentration, and v) Minimum Interior Paint Condition.

All five variables show similar standardized regression coefficients. The coefficients for age and yard soil lead are similar to those noted at the BHSS, indicating a consistent dose-response relationship. Typical blood lead levels decrease by about 0.34 µg/dl per year of age. Blood lead levels increase by an average of 0.7 µg/dl per 1000 mg/kg lead in home yard soil. Compared to the BHSS, where blood lead levels increase by an average of 2 µg/dl per 1000 mg/kg lead in home yard soil (using the simple multiple regression model), and other reported literature values of 1.5-2.2 µg/dl per 1000 mg/kg lead in home yard soil, the Basin yard soil coefficient falls into the lower end of reported slope coefficients (TerraGraphics 2000a, Succop et al. 1998). Xintras

(1992) also summarized soil slope coefficients from other mining and lead communities at 0.6-12.6 µg/dl per 1000 mg/kg lead in yard soil.

The dust mat dust loading relationship was noted in the *Coeur d'Alene River Basin Environmental Health Exposure Assessment* (IDHW 1999). Blood lead levels increase by about 0.16 µg/dl per mg/m^2/day of lead loading to the home. At a constant typical dust loading rate of 1 g/day, or similar amount of dust entering the home, this increase is about 0.9 µg/dl per 1000 mg/kg. Geometric mean dust loading rates range from 1.04 g/m^2/day in Osburn to 2.31 g/m^2/day in Burke/Nine Mile. Geometric mean dust mat lead concentrations range from 318 mg/kg in Lower Basin/Cataldo to 1781 mg/kg in Burke/Nine Mile (Table 6-17).

The significance of the paint variables adds additional information. The Median Exterior Paint Concentration is the median XRF reading for all exterior paint lead measurements. This variable may be indicative of an additional lead source to children. However, its significance in the presence of yard soil and house dust lead loading suggests a separate pathway may be present or the variable may be a surrogate for house age and community-specific effects. The effect of this variable is about 0.52 µg/dl per mg/cm^2. Geometric mean exterior paint concentrations range from 0.03 mg/cm^2 in Kingston and the Side Gulches to 0.22 mg/cm^2 in Wallace (Figure 6-7b).

The significance of Minimum Interior Paint Condition is also interesting. This value represents the best single paint condition noted for a home. Most homes (79%) have a Category 1 value, indicating at least the painted surface in one room was in good condition. However, there are some number of homes (19%) where the best paint condition noted was Category 2 (chipping and peeling on a few surfaces in all rooms), or 3 (indicating all paint was in chipping and peeling condition on most surfaces) (2%). These data suggest that children living in homes with extraordinarily poor paint condition exhibit significantly higher blood lead levels. Children in homes in Minimum Category 2 would exhibit about a 2 µg/dl greater response than those in Category 1. Those in Category 3 would show about 2 µg/dl greater response than Category 2. This variable reflects a potential source of lead from which children could consume paint particles directly or through incorporation in the house dust, and may also be a surrogate for home hygiene and socioeconomic and housing quality status.

Dust, Soil, and Paint Lead Relationships

Similar stepwise regression analyses were conducted for dust lead, soil lead, and paint lead source variables. Dependent variables were dust mat lead concentration, lead loading rate, and vacuum bag lead concentration. For these analyses, soil and dust lead concentrations were log transformed to meet the basic statistical assumptions underlying regression analysis.

Tables 6-22a-b show two candidate regression models for mat lead concentration following stepwise selection of candidate independent variables. In Table 6-22a the first model explains 44% of the variation in log mat lead concentration using four variables: i) log of the yard soil lead concentration, ii) the maximum interior lead XRF reading, iii) the minimum interior paint condition, and iv) exterior median lead XRF concentration. Three of these variables were also significantly related to blood lead levels in the preceding analysis. Interior paint lead concentration was not significant in the blood lead regression model. These model results suggest that both soil and paint are potential sources of lead in house dust. The relative sums-of-square, F-statistic and standardized regression coefficients suggest that soil is the largest contributor with both interior and exterior paint having similar, but lesser, significance than soils. Homes with extraordinarily poor paint condition also show increased mat dust lead concentrations.

Table 6-22b shows the same model with the community geometric mean soil concentration variable added. The inclusion of this variable in the model results in loss of significance for both interior and exterior paint lead concentration variables. Table 6-22c shows the final model form excluding the non-significant variables. This model explains 47% of the variation in dust mat concentrations as opposed to 44% in the previous form including paint lead concentration. These results show that yard soil continues to be the most significant contributor to entryway dust lead followed by soils from the community at large. These results possibly suggest that community mean soil lead concentrations and paint lead concentration co-vary as a function of housing and community age and that any major effect of paint lead on dust lead concentration is manifested through soils.

The model in Table 6-22c suggests about a 0.8 mg/kg decrease in dust mat lead concentration per mg/kg decrease in yard soil concentration at typical values. This is similar to the effect of soil lead on house dust lead levels noted in the BHSS (TerraGraphics 2000a).The same model suggests that dust mat lead levels in homes with poor minimum paint condition would have dust lead levels typically 500 mg/kg greater per condition code category, and that dust lead concentration reductions would parallel decreases in community mean soil lead concentration.

Table 6-22d shows the select regression model form for dependent variable log (dust mat lead loading rate). Four variables are significant in describing 36% of the variation in lead loading rate. The log of yard soil lead concentration was again the most significant variable followed by the interior paint minimum condition, the community mean soil concentration, and the interior paint maximum lead concentration by XRF. In this case, the maximum interior lead XRF reading remained significant at p=0.02 in the presence of community soil. Exterior paint lead content was not significant.

Table 6-23 shows the select regression model for dependent variable log vacuum bag lead concentration. This analysis is limited by the number of observations containing both vacuum bag and paint XRF readings; two observations were identified as outliers and were excluded from the statistical analysis. Only 68 observations are available for this analysis. About 55% of the variation in vacuum bag lead concentration is explained by log transformed yard soil and dust mat lead concentrations, and the maximum interior paint lead concentration shown in Table 6-23. This analysis suggests that vacuum bag lead concentration is largely related to dust mat lead concentrations, with yard soil lead content and the maximum interior paint XRF reading contributing at the p=0.01 and 0.03 significance level, respectively. The empirical models in Table 6-22c and 6-23 are used in Section 6.7.6 to project post soil remediation dust lead concentrations.

6.4.3 Summary of Site-Specific Lead Health Analysis

These site-specific analyses add considerable insight into the blood lead and environmental source relationships ongoing in the Basin. Blood lead levels are strongly correlated to dust lead loading, yard soil lead, and exterior paint concentrations. Interior paint condition is a significant risk co-factor that is also related to dust mat lead concentration. The slope of the blood soil to yard soil relationship of 0.7 µg/dl per 1000 mg/kg soil lead is similar to that observed at the BHSS and other mining related sites. Succop et al. (1998) using simple regression techniques estimated a yard soil slope coefficient of 1.5 µg/dl per 1000 mg/kg soil lead; however, by using more sophisticated statistical techniques a yard soil slope coefficient of 2.2 µg/dl per 1000 mg/kg soil lead was observed. The relationship with dust lead loading rate was previously noted in the *Coeur d'Alene River Basin Environmental Health Exposure Assessment* (IDHW 1999). However, this measurement has not been reported in dose-response analysis at other sites, and was not utilized at the BHSS until remediation was largely complete in Smelterville.

Most of the effect of soil lead on blood lead is likely manifested through house dust. Dust lead loading rate is the most significant variable in describing blood lead levels, explaining more than 40% of the variation in a single variable model. The variable is made up of two components. Those are dust loading rate, or the amount of dust that collects on an entryway mat per day, and the lead concentration of that dust. Examination of the database suggests that both components are important in exposure assessment for the Basin. Figures 6-9a-c show geometric means for both components and the product lead loading rate for each geographic subarea.

Figure 6-9b shows that the 1996 dust loading rate, or amount of dust entering a home, is highest in the Burke/Nine Mile area at 2.31 g/m^2/day, followed by Wallace and Mullan near 1.40 g/m^2/day, Silverton and Osburn in the 1.00 to 1.30 g/m^2/day range, Side Gulches and Kingston at 1.44 g/m^2/day and 1.21 g/m^2/day, respectively, and the Lower Basin at 1.54 g/m^2/day. A similar pattern is also noted in the lead concentration of these dusts, shown in Figure 6-9a. Mean dust mat lead concentration exceeds 1200 mg/kg and 1700 mg/kg, respectively, in Mullan and Wallace, and is near 900 mg/kg in the remainder of the Basin above the BHSS, and is above 600 mg/kg in Kingston and 300 mg/kg in the Lower Basin.

The combination of these effects results in extremely high lead loadings in Burke/Nine Mile area, nearly five times that in the Silverton to Kingston reach. Wallace also shows especially elevated lead loading rates, nearly twice the majority of the other geographic subareas. The remainder of the areas show similar lead loading rates, excepting the Lower Basin, with rates about 40% less than the Kingston to Silverton reach. Lead loading rate, (from 1996) is shown in Table 6-17.

Mean blood lead levels and percent of children to exceed critical toxicity criteria follow a similar pattern with highest levels in Burke/Nine Mile followed by Wallace. Mullan, Silverton, Osburn and Kingston all have similar levels. The exception to this trend is the Lower Basin where lead loading is notably lower, but blood lead levels and toxicity are similar to Wallace.

These results suggest that the combination of dusty conditions and high lead content of dusts is the primary determinant of blood lead absorption in the upper Basin. Lead loading rate, in turn, is most related to outdoor yard soil lead content with this variable alone explaining 42% (of the 47%) of the variation in mat lead concentration. The slope of the mat dust to yard soil lead concentration relationship is about 0.8. Interior paint condition code is also significant with respect to dust mat lead concentration, indicating as much as 500 mg/kg increase in poor condition homes. Exterior and interior paint concentration is significant when added to the previous variables in regression analysis, but becomes non-significant in the presence of community mean soil concentrations. This relationship is difficult to interpret because both paint concentration and community wide contamination levels are higher in older communities. However, this relationship is potentially important as the model indicates house dust lead levels are sensitive to community wide soil concentrations, as was noted at the BHSS and other sites. Elevated blood lead levels in the Lower Basin indicate that other pathways or sources may be present in that geographic area.

The same variables, yard and community mean soil concentration and interior paint condition remain significant with respect to lead loading rate. Yard soil lead concentration is the strongest determinant in lead loading followed by community mean soils and interior paint condition. Maximum interior paint lead concentration also becomes a weaker, but significant, determinant of lead loading.

Finally, vacuum bag dust lead levels are dependent on dust mat lead concentration, outdoor yard soil lead content, and indoor paint lead concentration. Generally, vacuum bag dust lead concentration ranges from about 60% to 80% of dust mat lead content as shown in Figure 6-11. These overall results suggest a complex pathway of exposure. Blood lead levels are most related to lead loading in the home, followed by independent effects of yard soil lead, and paint lead condition and exterior lead content. The dust lead pathway is most influenced by outdoor soils, but is augmented by paint contributions particularly in older homes in poor condition. The overall effect is exacerbated by dusty conditions in Burke/Nine Mile and to a lesser extent in Wallace. Much less of a problem is noted with respect to dustiness or dust concentrations in the Lower Basin.

6.5 BASELINE AND INCREMENTAL LEAD EXPOSURE INTAKE RATES

6.5.1 Exposure Routes Considered

Lead intake rates are developed for the identified pathways and exposure routes in a format compatible with input to the IEUBK Model and USEPA Adult Model for lead that predict geometric mean blood lead levels. Intake rates were calculated using the Central Tendency (CT) exposure factor values for input into both models. CT values represent a typical or average case (or 50% percentile). Exposure routes and intake estimates are developed for Suburban/Rural community scenarios for the local resident population and for Native American scenarios for Coeur d’Alene Tribe members practicing traditional or current subsistence activities.

Current Resident Population

Intake rates for the resident population are developed in both baseline and incremental exposure format. Baseline exposure refers to typical everyday activities associated with residential life in the Basin. Incremental exposures are associated with specific activities (e.g., recreational or occupational) that can add to the baseline exposure.

Baseline exposure routes for lead in the residential environment for both children and adults include:

- incidental ingestion of soils/sediment/sub-surface soils,
- incidental ingestion of house dusts,
- ingestion of drinking water,
- inhalation of dust in air, and
- consumption of market basket foods.

Incremental exposures are addressed in four major categories: i) occupational, ii) recreational, iii) local foodstuff, and iv) consumer goods.

Intake rates for adults in occupational settings outside the mineral processing industry include:

- incidental ingestion of soils, and
- inhalation of dust in air.

Recreational intake rates for children and adults include:

- incidental ingestion of soils/sediments,
- incidental ingestion of surface waters,
- ingestion of drinking water, and
- inhalation of dust in air.

Intake rates associated with local foodstuffs for children and adults include:

- consumption of fish from the lateral lakes and Spokane River for Tribal Scenarios,
- consumption of locally grown vegetables.

Lead intake rates for consumer goods include:

- ingestion of lead-based paint other than that manifested through house dust for young children.

Native American Scenarios

Coeur d'Alene Tribal practices are such that the risk assessment is not easily sub-divided into baseline and incremental activities. Tribal lifestyle and exposure pathways are discussed in Section 3.0. The resident riparian lifestyle in the Traditional Subsistence scenario and the harvest techniques employed throughout tribal history represent holistic practices that encompass all activities in an overall lifestyle. Fully addressing potential Native American lead exposures within the Basin requires consideration of routes of exposure not included in other scenarios in the HHRA. The tribal riparian lifestyle has the potential for significant prolonged exposures to both sediment and water. One example could be the harvest of the water potato (*Sagittaria spp.*) at the mouth of the Coeur d'Alene River. These activities also involve women of reproductive age accompanied by small children for extended periods of time.

The same exposure routes are evaluated for both the Traditional Subsistence scenario and the Current Subsistence scenario. For evaluation of the human health risks associated with each scenario, the exposure factors will reflect the difference for each exposure route. Generally, the exposure frequencies for the Current Subsistence are reduced from the values used in the Traditional Subsistence scenario.

Intake rates developed for the tribal scenarios are:

- incidental ingestion of soil/sediment,
- dermal contact with soil/sediment (non-lead only),
- ingestion of surface water as drinking water,
- incidental ingestion of surface water during recreational activities,
- consumption of fish, and
- consumption of water potatoes.

The remainder of the tribal pathways, discussed in Section 3.2.4, are not quantified in this risk assessment, due to limitations on available data or relatively insignificant contribution to the overall risk to human health. Data associated with certain exposure routes may be available, but are considered insufficient to characterize media contaminant levels. Example calculations also showed some pathways do not significantly contribute to human health risk when compared to others being quantified.

Table 3-19b shows those Native American exposure routes that will be considered either quantitatively or qualitatively in the HHRA.

6.5.2 Developing Baseline Intake Rates for the Resident Population

Children's Baseline Intake Rates

Baseline intake rates estimate the amount of lead taken into the body through everyday, normal activities undertaken by the general population. These rates apply to everyone. These are calculated by multiplying the amount of soil, dust, food, and water ingested by the amount of lead contained in each medium.

Baseline Ingestion and Inhalation Rates

Baseline lead intake rates are calculated using the ingestion rates developed within the IEUBK Model and USEPA Adult Model for lead. These rates will correspond with the default ingestion, consumption, and inhalation parameters indicated in current USEPA Guidance. Using default assumptions indicates that values that characterize children and adults throughout the United States are applicable to estimate the amount of soil, dust, food, and water consumed in typical activities for the resident population in the Basin. Tables 6-24a-b, respectively, show default ingestion and inhalation rates for children from the IEUBK Model guidance and default parameters for adults from the USEPA Adult Model for Lead.

Soil and Dust Ingestion

Both the IEUBK Model and USEPA Adult models combine soil and dust ingestion rates into a single input variable. The relative contribution is partitioned, or divided, among the various sources of soil and dust available to the population. Two initial partitions were developed for application to the IEUBK Model analysis. The first scenario is the USEPA guidance default partition of 55% house dust : 45% yard soil using the individual home yard as the soil exposure unit. This application is referred to as the "EPA Default Model". The second scenario corresponds to the 40% house dust : 30% yard soil : 30% community soil partition utilized at the Bunker Hill Superfund Site (BHSS), referred to as the "Box Model" or "40:30:30 Model". The Box Model is described in more detail in Appendix Q.

Drinking Water Ingestion

Default drinking water concentrations are included in both the EPA Default Model and Box Model for Community Mean applications. Observed concentrations are employed in the Batch Mode application with the community geometric mean concentration substituted for missing observations.

Inhalation of Dust in Air

Default values will be used for inhalation of dusts. Support calculations demonstrate that the relative contribution of this route does not justify additional characterization. Inhalation intakes assume similar RME exposure factors and are estimated using methods from EPA Exposure Factors Handbook (USEPA 1990c). The inhalation exposure for airborne contaminants is estimated by the following formula:

$I_{(inhal)} = C \times IR \times EF \times ED \times EP$

Where:

$I_{(inhal)}$	=	Inhalation intake (µg/year)
C	=	Concentration of contaminant (µg/m^3)
IR	=	Inhalation rate (2.1 m^3/hr)
EF	=	Event frequency (5 days/wk)
ED	=	Event duration (39 weeks/yr)
EP	=	Event period (8 hrs/day)

Assuming 0.1 µg/m^3 air lead concentration consistent with BHSS observations and a moderate ventilation rate for average adults, yields a ventilation intake of 328 µg. Assuming 50% retention and absorption in the lungs results in 164 µg of lead absorption per nine month construction season. This represents approximately 4% of the total baseline intake rate for lead in the Lower Basin, compared to 1% in Wallace. Neither dermal nor inhalation exposure routes are considered in the remaining analyses.

Dietary Lead

Default dietary intake rates representing the typical US market basket are included in both model forms. National default values are used for baseline dietary intake rates throughout these analyses.

Summary Baseline Intake Rates

Tables 6-25a-b summarize estimated mean typical daily lead intake rates for each subarea in the Basin for both the EPA Default and Box Model scenarios. Tables 6-25a-b and Figures 6-12a-b show example intake rates for 4 year old children. Appendix P contains similar rates for other ages. Estimated Baseline lead intake for 4 year old children based on geometric mean conditions in each subarea range from a low of 30 µg/day in the Lower Basin to 99 µg/day Wallace for the EPA Default scenario. Generally, the Box Model intake rates are slightly lower ranging from 27 µg/day to 95 µg/day for the same subareas, respectively. Estimated mean intake rates are considerably higher in the upper Basin ranging from 85 µg/day to 99 µg/day east of and including Wallace, 52 µg/day to 64 µg/day in the Silverton to the BHSS reach, 43 µg/day to 46 µg/day in Kingston and 27 µg/day to 30 µg/day in the Lower Basin.

All of the Baseline intake rates are dominated by the soil and dust component. Air, drinking water and dietary lead intake for the typical child total about 8.5 µg/day or about 10% of the total baseline intake in the upper Basin and about 30% for the Lower Basin. In the EPA Default scenario, house dust contributes about 50% to 60% of the total intake in all areas, ranging from 17 µg/day in the Lower Basin to 55 µg/day in the upper Basin. Yard soil is estimated to contribute only 5 µg/day typically in the Lower Basin to 35 µg/day in Wallace in the EPA Default scenario. In this scenario, yard soil accounts for 17% of the total estimated intake in the Lower Basin to 35% in Wallace.

The percentage contribution to total intake differs somewhat for the Box Model scenario. In this scenario, house dust contributes slightly less than in the EPA Default scenario ranging from 37% to 47% of the total lead intake throughout the Basin. Soils contribute from 26% in the Lower Basin to 48% in the upper Basin. However, in the Box Model the combined total of soils from the individual home yard and the greater community contribute a similar amount to overall intake.

Adult Baseline Intake Rates

Baseline intake rates for adults are shown in Table 6-26 based on a typical soil and dust ingestion rate of 50 mg/day comprised of 1/2 soil, 1/2 dust. However, these results are not used in the subsequent analyses because actual reproductive aged female blood lead levels are available for each geographic subarea for input to the Adult Model for Lead (See Table 6-8b).

Total baseline intake rates for lead from soils and dust range from a mean of 11 µg/day in the Lower Basin to 45 µg/day in Wallace or about half that determined for children. Estimates range from 19 µg/day to 23 µg/day in the areas near the Box (Kingston to Silverton), and 39 µg/day to 41 µg/day in the upper Basin. In all cases the majority of baseline lead intake is from house dust.

6.5.3 Developing Incremental Intake Rates for the Resident Population

Incremental lead intake rates refer to the amount of lead taken into the body during activities in which only certain members of the population engage. These individuals either consume more soil, dust, water, food, than the general population or those media have higher lead content.

Incremental lead intake rates are determined for a variety of potential activities that could significantly add to the amount of lead taken into the body. These rates are developed on an activity specific basis for both a typical or average case called the Central Tendency (CT) or a worst case called the Reasonable Maximum Exposure (RME) estimate. Initial soil, dust, food, and water ingestion and inhalation values used for these intake calculations correspond to those developed for the non-lead risk assessment. Specific adjustments have been made to accommodate lead-specific factors or input from reviewers, the public or other interested parties.

Estimated incremental intakes are presented in tabular form including both the absolute intake value and the percent increment above baseline. In this manner, risk managers can evaluate the relative effect that incremental activities could have on baseline intake rates.

Occupational Intake Rates

Potentially significant occupational activities have been classified according to the likelihood of encountering soil and dust exposures in the normal course of employment. Three classification levels are proposed: nominal, medium, and intensive corresponding to the following qualitative evaluation. Nominal exposures are consistent with typical residential behaviors and activities, or those occupations that have no special or particular relationship with contaminated soils. Nominal occupational exposures are not evaluated in this risk assessment. The medium classification corresponds to those individuals whose jobs involve periodic exposure to soil sources, such as public property maintenance, typical construction workers, or laborers.

Intensive occupational exposure refers to individuals whose employment specifically involves exposures to soils such as landscapers; farmers and agricultural workers; remediation workers; construction workers routinely involved in excavation, demolition, or site development; or utility or road workers. Mineral industry workers are specifically excluded in the occupational scenario, as exposure to lead is specifically regulated by occupational health authorities. Although individuals working in the mining industry are not evaluated in this HHRA for lead exposure in the workplace, they are considered in the residential scenario.

Soil and dust ingestion and inhalation rates, exposure frequencies, and contact times for these activities do not correspond with those developed for the non-lead portion of the risk assessment. Recommended ingestion rates from USEPA Adult Model for lead ingestion rates are employed for all adult lead health risk calculations. Comparison to non-lead intake parameters are shown in Tables 6-27 a-c. Lead intake rates for medium classification are represented by the CT estimates, with the RME representing the more intense exposure category. No estimates have been developed for nominally exposed populations.

Table 6-27a shows intake parameters used for the non-lead portions of the risk assessment for the RME and CT estimate. For lead risk assessment, alternate values corresponding to the EPA Adult model recommendations of 200 mg/day RME and 100 mg/day CT are used as noted in Table 6-27b. Table 6-28a shows typical RME and CT lead intakes respectively, for community mean soils by geographic subarea. Included in these tables are the estimated baseline intake rates assuming a 50 mg/day soil/dust ingestion rate. These results suggest that lead intake for an adult employed in medium intensity occupational activities involving typical residential soils would increase from 25% to 43% above baseline using the non-lead parameters. For the intense contact or RME activities lead intake would increase by 1.8 to 2.9 times. Table 6-28b and Figures 6-13a-b show similar lead intake estimates using the EPA Adult Model recommended ingestion parameters. These results suggest about 20% over baseline for CT and one to two times baseline for RME ingestion rates, respectively.

Tables 6-29a-b show estimated occupational intake rates associated with different potential soil concentration intervals. Incremental intake rates are shown both seasonally, based on the RME and CT outdoor work duration, and averaged annually. Seasonally adjusted intake rates for unprotected work in 2000 mg/kg soils, for example in Table 6-29a, are 246 µg/day for medium exposure and 419 µg/day for intensively exposed occupations. Averaged over the year (12 months) the respective values are 47 µg/day and 321 µg/day. Table 6-29a corresponds to non-lead ingestion rates. Table 6-29b shows adult occupational exposure for lead ingestion rates.

Tables 6-11 through 6-16 show typical soils concentrations for each residential area, waste piles in the upper Basin and soils/sediments in the upper Basin and Lower Basin floodplain. The appropriate estimated intake rates for occupational activities associated with these soils have been included in Table 6-30b. For example, the estimated annual average 50th percentile soil concentration CT intake rate for a median intensive occupation in the Lower Basin floodplain is 37 µg/day.

This baseline intake rate is also included in Table 6-30c. The estimated baseline intake rate for the Lower Basin is 10 µg/day. The combined baseline and incremental rate for an intensively exposed worker in the Lower Basin floodplain is 47 µg/day. This rate is 366% or 3.7 times increase over baseline for this subarea. Other examples in Tables 6-30b-c show the incremental and combined intake estimates and percent increases for occupational exposures to various soils throughout the Basin.

Recreational Activities Intake Rates

Proposed classifications of recreational activities are similar to the occupational categories. However, additional potential exposure routes, at-risk population factors, and exposure frequencies are considered.

Recreational activities have been classified according to the likelihood of encountering contaminated environmental media. With regard to soils and dusts, these activities can also be considered nominal, medium or intense. Nominal activities are considered consistent with baseline residential activities and will not be developed as incremental exposures. Nominal exposures to particular sources within a community (e.g., a neighborhood playground) are considered to be included in the soil partition for the baseline exposure. Medium intensity activities include picnicking, hiking, fishing, exploring, etc. Intense recreational activities include such practices as dirt biking, fort building, beach activities, four-wheeling, gardening, landscaping, etc., that involve deliberate and continued contact with soils.

Ingestion of surface waters is not considered as a substitute source for typical drinking water during recreational activities. Surface waters are addressed as an incidental source of ingestion of suspended sediments during swimming and beach activities. Inhalation of contaminated dusts are considered incidental to soil/dust ingestion and are not developed as a separate pathway.

Intake rates are developed for sub-populations including young children and reproductive-aged women. Three exposure frequency categories are considered; incidental, seasonal, and year-round. Because significant increases in blood lead levels can be associated with short-term exposures on the order of a few weeks or months, only incidental and seasonal estimates are developed.

Soil and dust and surface water ingestion rates, exposure frequencies and contact times for these activities correspond with those developed for the non-lead portion of the risk assessment. No estimates are developed for nominally exposed populations as these exposures are incidental to the baseline.

Exposure point concentrations for recreational activities are developed at successive 500 mg/kg concentration intervals for soils and dusts. This results in classification of particular recreational areas according to lead content of the environmental media and estimated incremental intakes for both medium and highly exposed recreational groups.

Common Use Areas (CUAs) and other recreational locations are also classified by types of recreational activity supported. Factors determining type of activity include the following criteria:

- Intensity of use - nominal, medium, intensive.
- Sensitive population - frequented by young children, older children or adults only.
- Frequency of use - incidental or seasonal.

From this classification scheme, incremental intake estimates associated with particular recreational activities and locations can be obtained by applying the site-specific soil lead concentration and activity characteristics.

Incremental Soil Lead Intake. Table 6-31 summarizes the CT intake parameters for soil and dust media for the non-lead portion of the risk assessment. CT estimates are used for the medium exposure category and RME estimates for the intensive recreational activities.

Tables 6-32a-c summarize incremental intake estimates due to recreational activities for soils and sediments at successive potential concentration levels. Incremental intake rates are shown both seasonally, based on the number of weeks for each recreational activity, and averaged annually. Tables 6-32a-b show, respectively, medium (CT) and intensive (RME) intake rates for children. Seasonally adjusted intake rates for 1500 mg/kg soils in Upland Park areas, for example, are 13 µg/day for medium exposure and 64 µg/day for intensively exposed children's recreational activities. Averaged over the year these rates are 8 µg/day and 42 µg/day, respectively.

Similar values for adults are found in Table 6-32c. For 1500 mg/kg lead soils in Upland Parks, the seasonally adjusted rates for adults are 5 µg/day and 19 µg/day, for CT and RME conditions, respectively. Annual rates are 3 µg/day and 12 µg/day, respectively.

Incremental Surface Water Intakes. Table 6-33 shows intake factors for incidental ingestion of surface water in recreational scenarios. Tables 6-34a-b show incremental lead intake rates associated with potential surface water lead concentrations for disturbed sediment sites, respectively, for children and adults. These tables show seasonally adjusted and annual average incremental lead intakes associated with potential surface water concentrations at Common Use Areas and neighborhood streams for children. For example, a site with a characteristic surface water concentration of 5000 µg/l lead concentration would result 21 µg/day seasonal and 7 µg/day annual average lead intake for the CT recreational situation for children. Corresponding RME incremental intakes are 43 µg/day and 13 µg/day, respectively. For the neighborhood scenario at the same concentration, CT estimates are 43 µg/day seasonal and 20 µg/day annual. RME estimated intakes are 86 µg/day and 39 µg/day, respectively.

Table 6-12a shows typical concentration of lead in water and suspended sediment at public beaches in the Basin and those for local residential areas. Tables 6-14 through 6-16 show typical soil and sediment concentrations for neighborhood stream sediments, CUAs, and waste piles in the upper Basin.

Incremental Intake Rates for Upland Park CUAs. The appropriate estimated annual average CT intake rates for recreational activities associated with these soils have been included in Tables 6-35a-c for medium exposed 0-6 year old children. Table 6-35a also shows percentile surface soil lead concentrations for Upland Parks in the Mullan area, the mid-reach of the upper Basin from Wallace to the BHSS, and the Lower Basin from Kingston to Harrison. There are no Upland Park CUAs for the Burke/Nine Mile Canyon sub-unit. Incremental recreational increases for this geographic subarea are discussed under neighborhood sediments below.

Table 6-35b shows incremental lead intake rates associated with the respective percentile soil concentrations. Table 6-35c shows medium (CT) and reasonable maximum exposure (RME) intake rates (i.e., 50th and 95th percentile) compared to baseline intake rates for each geographic subarea. CT and RME annual intake rates are calculated using CT soil ingestion rates from Table 6-31. The RME intake value in Table 6-35c refers to the 95th percentile media concentration calculated for the geographic area. Only CT ingestion rate estimates are developed for inclusion in IEUBK Model blood lead predictions in Section 6.6. Children practicing RME soil ingestion rates would have considerably higher lead intake rates than those indicated in Tables 6-35b-c.

The results in Table 6-35c can be used to assess relative intake rates. For example, the estimated annual intake rate for a medium (CT) child recreation in the Lower Basin floodplain (mean soil concentration 3415 mg/kg lead) is 19 µg/day. The baseline intake rates are also included in Tables 6-35b-c with the incremental intake rates. The combined baseline and incremental rate for a medium exposed child in the Lower Basin floodplain is 49 µg/day (19 µg/day incremental +30 µg/day baseline) using CT values. This rate is a 63% increase over baseline intake for the typical four year old child playing in 50th percentile soil lead levels in the Lower Basin.

Other examples in Tables 6-35b-c show the incremental and combined soil and dust lead intake estimates and percent increases over baseline for recreational exposures throughout the Basin. Generally, CT or typical incremental intake rates at 50th percentile concentrations are modest (5 to 7 µg/day) east of the BHSS. This represents a less than 10% increase over baseline for these areas. In the Lower Basin, incremental CT intakes are larger (19 µg/day), representing approximately a 40% to 60% increase over baseline rates.

RME results for 95th percentile concentrations in the upper Basin, however, are substantial in the mid-reach area, as a small number of CUAs are severely contaminated. RME (95th percentile concentration) upland park CUA intakes represent about 70% to 125% increase over baseline in these areas. RME incremental intakes in the Lower Basin are about 50% greater than CT increments, and are about twice the baseline.

Incremental Intake Rates for Neighborhood Sediments and Surface Water. Potential lead intake rates associated with recreational activities in or near streams in the immediate neighborhood of residences are shown in Tables 6-36a-c in the same manner as upland parks in Tables 6-35a-c. Percentile lead concentrations are shown in Table 6-36a for both surface water and sediment and corresponding lead intake rates are calculated in Table 6-36b. CT and RME intake rates are compared to basline by geographic area in Table 6-36c. Generally, neighborhood streams contribute little to overall intake, as suspended sediment concentrations are relatively low compared to CUAs. Principal incremental intakes in this scenario are due to stream sediments and are most significant in the Burke/Nine Mile subarea (13 µg/day annual average) and the mid-reach areas (8 µg/day). These constitute almost a 15% increase over baseline for the CT situation. For the RME, substantial contributions to overall exposure are noted for Burke/Nine Mile (221 µg/day or nearly tripling baseline) and Mullan (45 µg/day), a 50% increase over baseline.

Neighborhood sediment and surface water contributions for the Lower Basin are low because these types of exposures generally occur at CUAs (discussed above) or public beaches (discussed below), rather than neighborhood streams as defined for the upper Basin.

Incremental Intake Rates for Public Beaches. Combined sediment and surface water lead intakes for public beaches included among the CUAs are shown in Tables 6-37a-c for children age 0-6 years. As opposed to neighborhood streams, these sites represent public access areas frequented by both Basin residents and visitors. As a result, the data have been combined and are uniform increments for all geographic subareas. The CT incremental lead intake for these sites is 19 µg/day for both sediment and surface water ingestion. The RME sediment intake rate is 30 µg/day lead and the corresponding surface water incidental ingestion rate is 42 µg/day, respectively. The combined CT rate adds 40% to 45% to the baseline intake for an upper Basin child, 60% to 70% for a mid-reach child east of the BHSS, 84% in Kingston, and 128% in the Lower Basin. The RME is a substantial contribution, nearly doubling baseline rates east of Wallace, more than doubling baseline in the mid-reach, and tripling baseline intake in the Lower Basin.

Incremental Intake Rates for Waste Piles. There are reported incidents of children playing on mining industry waste piles in the Burke/Nine Mile and Mullan subareas. Tables 6-38a-c show percentile lead concentration data for waste piles sampled in these areas, associated intake estimates and comparison of CT and RME intake to baseline. These results show that the assumed contact rates result in little CT incremental exposure in Mullan, although at 95th percentile concentrations there is a 13% increase over baseline in Mullan. Potential exposures in the Burke/Nine Mile area, however are significant, ranging from a 14% increase over baseline at the 50th percentile concentration to a 160% increase for the 95th percentile.

Lead Intake Rates from Local Foodstuff. Ingestion of lead associated with local foodstuff includes consumption of garden vegetables and fish from the lateral lakes area. Recommended USEPA typical and RME consumption rates for fish fillets are used for adults; child consumption rates were derived from the adult values by calculating a consumption rate in units of grams per kilogram per day then multiplying by the child body weight (15 kg). Lead intake estimates for consumption of local garden produce have also been developed using recommended USEPA default rates. Table 6-39 summarizes the intake parameters for garden produce and sport fish ingestion consistent with the non-lead portion of the risk assessment. Table 6-40a-b shows typical

CT and RME child incremental lead intake rates for homegrown vegetables. The CT and RME estimates are based on the 50th and 95th percentile lead concentrations for fresh weight vegetables developed in Table 6-10. Both estimated CT and RME incremental intake rates can add substantially to baseline intakes. Consumption of 50th percentile concentration homegrown vegetables on a regular basis could increase total estimated intake by 24% in Wallace to 79% in the Lower Basin. Intake rates from 95th percentile produce are extreme. Table 6-40b shows typical CT and RME adult incremental lead intake rates for homegrown vegetables.

Tables 6-41a-b show similar results for sport fishery intake rates for children and adults. For adults typical incremental intake rates are modest. For children typical local fish consumption would increase total baseline intake by 1% to 12%.

Summary of Incremental Lead Intake Rates. Tables 6-42a-b and 6-43a-b and Figures 6-14a-d summarize relative intake rates for various incremental activities for children and adults, respectively.

6.5.4 Developing Intake Rates for the Coeur d'Alene Tribe

Tables 3-26a-b, respectively, show exposure factors for the Traditional and Current Subsistence scenarios for the Coeur d'Alene Tribe. Figures 6-15a-b summarize estimated Tribal intake rates for children for each scenario, respectively. Adult intakes are summarized in Figures 6-16a-b.

Traditional Subsistence Intake Rates

Tables 6-44a-b show estimated lead intake rates, respectively, for children and adults for traditional subsistence pathways and percentiles for media concentration levels. Tribal intakes are not appropriately characterized as baseline or incremental, as the Tribal lifestyle is cumulative and encompasses all pathways simultaneously. As a result, Table 6-44 entries are arranged by media and percentile and are summed for corresponding percentile levels. This yields an estimated total intake rate for the sum of all like-percentile estimates. That is, all 50th percentile intakes from various media are combined for the 50th percentile total intake estimate. This method is likely appropriate for the CT estimate. However, the RME or any minimal intake estimate (e.g., 10th percentile) likely overestimates the upper confidence limit (UCL) and underestimates the lower limits, as the extreme rates for each pathway are less likely to coincide.

Total estimated intake rates are extremely high for both adults and children for all but the lowest percentile categories. Intake rates for the CT and greater media concentrations typically exceed 1000 µg/day for children and 2000 µg/day for adults. These intake rates are an order of magnitude higher than observed intake rates in the residential population or pre-remedial estimates at the BHSS. Especially considering how much of the potential intake is through dietary routes, these would be extremely hazardous levels.

Tables 6-44a-b show estimated intake rates for both non-food and foodstuff for children and adults, respectively. Each table is presented in two forms. The upper portion of the table shows intake calculations using whole fish data from the Spokane River and un-peeled water potatoes.

The lower portion shows fish fillet and peeled water potato lead content. The upper portion represents a worst case situation where fish would be consumed whole and un-peeled water potatoes are a surrogate for the entire vegetable matter portion of the diet. Such assumptions are not unreasonable, according to Tribal sources, as these practices may have occurred in times of famine during traditional existence.

The lower portion of the table uses fish fillet and peeled water potato data. Total intake rates are reduced by 50% to 80% (as compared to whole fish and unpeeled water potato), but these values are not typical of a true, traditional scenario of whole fish and unpeeled water potatoes. However, regardless of this significant adjustment, estimated CT intake rates exceed 1300 μg/day for children and adults and are nearly double for the RME situation. These intake rates are also extremely high, about five to ten times pre-remedial levels at the BHSS.

Current Subsistence Intake Rates

Current Subsistence lead intake rates are summarized in Tables 6-45 and 6-46, which are arranged in a format similar to the Traditional intake estimate tables. Figures 6-15a-b and 6-16a-b contrast estimated Traditional and Current subsistence intake rates. Seasonal lead intake rates for the CT estimate are 258 µg/day for children and 311 µg/day for adults assuming only fish fillet and peeled water potatoes are consumed. RME intake rates are approximately 2 times CT estimates. These rates are similar to pre-remedial total intake rates at the BHSS. However, a greater percentage of total intake for subsistence pathways is from dietary sources that would be more bioavailable.

For current subsistence families, the largest portion of intake is from ingestion of soils and sediments while engaging in subsistence activities on land and in disturbed surface waters. Consumption of whole fish or un-peeled water potatoes by current subsistence families would result in dangerously high intake rates for both children and adults.

6.6 ESTIMATED BASELINE BLOOD LEAD LEVELS

6.6.1 Childhood Baseline Blood Lead Levels

The estimated Baseline intake rates for children developed in Section 6.5.2 were input to the IEUBK Model for both the EPA Default and Box Model scenarios. Estimates of mean blood lead levels and the percent of children to exceed 10 µg/dl were obtained from these applications in both the community and batch mode of the IEUBK Model. The community mode models predict blood lead levels based on geometric mean soil and dust concentrations for each geographic subarea. These results are then compared to community mean blood lead observations. The batch mode utilizes all paired blood lead data, or only those observations that have accompanying soil and dust lead measurements. Mean blood lead levels are then projected for each individual observation and the results are aggregated to develop community means that are then compared to the observed blood lead results. As such, the observed mean blood lead levels are not necessarily the same for both model applications. Some of the blood lead observations included in the overall community mean calculations for the community mode do not have corresponding environmental data and are not included in the batch mode runs.

Community mode IEUBK Model Estimates

The community mode application of the IEUBK Model predicts outcome blood lead distributions from community mean exposures. In this mode, the default estimates of baseline dietary, air, and drinking water intakes were used and geometric mean soil and dust concentrations for each subarea were applied. Tables 6-11a-h summarize the soil and dust input database for this application.

The community mode application results in an estimated mean blood lead level for each age group. The percent of children to exceed the 10 µg/dl health criteria are calculated by applying a pre-determined geometric standard deviation to the mean. Tables 6-47a-c show predicted and observed mean blood lead levels and percent to exceed estimates for each subarea for various age groups.

Results for both the EPA Default and Box Model are shown. These models differ principally in the partition of soil and dust sources to overall intake and in the assumed bioavailability of soils and dusts. The differences in the soil and dust partition is discussed in Section 6.5.2. The EPA Default Model uses a 30% bioavailability estimate for soils and dusts, whereas the Box Model uses an 18% site-specific estimate derived in past analysis of BHSS blood lead monitoring results (USEPA 1994a, TerraGraphics 2000a). Appendix Q contains details regarding the development of and parameters included in the Box Model.

Table 6-47a shows observed and predicted blood lead levels for 0-84 month old children using the community mode. For the EPA Default Model, predicted mean blood lead levels exceed the observed geometric mean for all subareas except in the Lower Basin, where observed geometric mean blood lead levels are 25% greater than EPA Default model predictions. In the upper Basin, EPA Default predictions are 1.4 to 1.9 times greater than the observed concentrations.

For the community mode application of the Box Model, an opposite pattern is noted. The Baseline Box Model under-predicts blood lead levels in the Lower Basin by a factor of 1.8 for the geometric mean, or the model predicts about 55% the observed mean blood lead concentration in this subarea. In Kingston, the observed means are equal to the prediction. Upstream from the BHSS, the predicted concentrations range from 1.0 to 1.3 times the observed geometric means, with Burke/Nine Mile blood lead levels slightly under-predicted and the Side Gulches and Mullan showing similar over-prediction.

Comparisons of predicted and observed percentages of children to exceed the 10 µg/dl health criteria follow a similar pattern, also shown in Table 6-47a. The Baseline EPA Default scenario tends to overpredict the observed percentage by a factor of 1.8 to 4.3 in the areas east of Wallace. In the three easternmost geographic subareas, this model predicts 40% to 48% of children will exceed 10 µg/dl, whereas 10% of Mullan and 19 % of Wallace and 22% of Burke/Nine Mile children tested showed excessive levels. For the middle reach from Silverton to the BHSS the model predicts 15% to 21% exceedance where 0% to 11% of children were observed with greater than 10 µg/dl blood lead levels. The EPA default model under-predicts observed percent exceedance in the areas west of the BHSS predicting near 10% for Kingston and less than 5% for the Lower Basin, whereas 14% and 25% of children were observed with levels of 10 µg/dl or greater.

The community mode Box Model tends to predict the percentage of 0-84 month old children exceeding 10 µg/dl east of the BHSS fairly well. Estimates range from 15% to 19% east of, and including Wallace compared to 10% to 22% observed. From 3% to 5% of children in the Silverton to BHSS reach were predicted to exceed the 10 µg/dl criteria and 0 to 11% were observed. Downstream from the BHSS, the Box Model greatly under-predicts observed toxicity projecting less than 5% exceedance compared to 14% to 25% of children in this age group exhibiting levels of 10 µg/dl or greater.

With younger age groups, similar patterns of over- and under-prediction are noted, though the magnitude of difference is less (Tables 6-47b-c). The EPA Default Model continues to significantly over-predict observed blood lead levels in the area east of Wallace. The Box Model effectively predicts both mean blood lead levels and percent to exceed 10 µg/dl in this area. Mean blood lead predictions and observations are within 1.2 µg/dl (i.e., 1-20%). Percent to exceed 10 µg/dl estimates range from 25% to 32% compared to 17% to 46% observed for less than 2 year old children (Table 6-47b). Respective predicted and observed estimates for 1 to 5 year old children range from 20% to 25% percent predicted and 17% to 26 % observed (Table 6-47c).

In the reach from Silverton to the BHSS, the Box Model over-predicts observed 1-5 year old mean levels and under-predicts 2 year old levels by 0.3 to 1.3 µg/dl or generally within 10% to 20%. Percent to exceed the 10 µg/dl criteria predicted for two year olds ranged from 8% to 11% compared to the high of 19% observed in Silverton. For 1 to 5 year old children, the respective predictions were 5% to 8% compared to 0% to 13% observed. The EPA Default model over-predicts observed levels in the BHSS to Silverton reach by 1.2 to 2.0 times, or 25% to 97%.

West of the BHSS, both models significantly under-predict observed blood lead levels in the Lower Basin. Observed mean blood lead levels are more than twice those predicted by either model in the community mode. Similarly, neither of these models effectively captures the percent of children to exceed the 10 µg/dl health criteria in this geographic subarea. In the Kingston subarea, the EPA Default model over-predicts and the Box Model under-predicts observed levels. However, both models under-predict the percent to exceed criterion.

Batch mode IEUBK Model Estimates

Generally, when paired site-specific environmental and blood lead data are available, the batch mode application of the IEUBK Model more appropriately describes the distribution of blood lead levels. In the batch mode, each observation is sequentially applied to the model and the results are aggregated for the entire population. The batch mode was applied to the entire Basin population in a single run. Table 6-48 summarizes the characteristics of the input data set. A total of 445 observations were included in these model runs. Some modifications were made to the data set to maximize the number of observations available. Children aged 85 to 108 months were assigned an age of 84 months and retained for analysis. If either the soil lead or vacuum dust lead level was missing for any observation, the geometric mean value for that geographic subarea was substituted and the observation was retained. If both values were missing the observation was deleted. In cases where the tap water value was missing, the purged community geometric mean lead concentration was used.

Table 6-49 and Figures 6-17a-c and Figures 6-18a-c summarize the observed and predicted blood lead levels and percent of children to exceed the 10 µg/dl criteria Basin wide for three age groups. Overall, the batch mode of the EPA Default Model over-predicts observed blood lead levels by 23% for two-year olds, 47% for 1-5 year olds and 32% for all aged children. The Box Model performs more effectively in this mode predicting 5.4 µg/dl versus 6.2 µg/dl observed for two-year old, 5.1 µg/dl versus 4.9 µg/dl for 1 to 5 year olds, and 4.1 µg/dl versus 4.1 µg/dl observed for all children. However, the EPA Default Model consistently over-predicts, and the Box Model under-predicts, the percent of children to exceed the 10 µg/dl criteria.

Tables 6-50a-c show the results by geographic subarea. The observed mean blood lead levels, although similar, differ from those reported in the previous section due to differing number of observations included in the analysis. Results are reported for both the EPA Default and Box Model (40:30:30). The results are similar to the community mode model runs. Both arithmetic and geometric mean blood lead levels are over-predicted by the EPA Default model throughout the upper Basin. Predicted levels are more than two times observed concentrations in Mullan and Wallace and are approximately 50% higher in Burke/Nine Mile, Silverton, Osburn, and the Side Gulches. West of the BHSS, mean blood lead levels are better predicted by the EPA Default model. For Kingston, the arithmetic mean prediction is 5.0 µg/dl versus 5.7 µg/dl observed and 4.7 µg/dl predicted versus 4.3 µg/dl observed for the geometric mean. In the Lower Basin, the observed and predicted arithmetic means are 6.9 µg/dl and 6.8 µg/dl, respectively, and geometric means are 4.9 µg/dl observed and 4.2 µg/dl predicted.

In the upper Basin, the Box Model is an effective predictor of mean blood lead levels, generally over-predicting geometric means and predicting near or slightly below arithmetic means. The degree of over-prediction is greater from Wallace east and is minimal from Silverton to the BHSS. West of the BHSS, the Box Model tends to under-predict mean blood lead concentrations by 10% to 30% in the batch mode application.

A similar pattern is noted with percent toxicity predictions. Generally, east of Wallace, the batch mode EPA Default Model over-predicts the percent to exceed the 10 µg/dl health criteria, projecting 44% to 48% exceedance versus 13% to 22% observed. The Box Model projects 19 % exceedance for these communities. East of the BHSS, both models under-predict the percentage of children experiencing excess absorption. From Silverton to the BHSS, the Box Model also accurately predicts observed percent toxicity, projecting 4% to 8% to exceed versus 0% to 11% observed. The EPA default model predicts 16% to 26% exceedance in this reach.

West of the BHSS, both models under predict the percentage of children greater than or equal to 10 µg/dl. The EPA Default version estimates 10% and 20% exceedance, respectively, for Kingston and the Lower Basin, as opposed to 17% and 32% observed. The Box Model predicts 2% and 13%, respectively, for these areas.

Tables 6-50b-c, respectively, show similar predicted and observed batch mode results for the 9-month through 24- month and 9-month through 60-month old children's age groups. Although the number of observations become scarce for some age/geographic area groups, the results tend to parallel the community mode applications. Figures 6-17a-c show predicted and observed mean blood lead levels for each age group. These figures illustrate that, in general, the Box Model provides a better prediction of observed levels in the upper Basin, while the EPA Default Model performs better in the Lower Basin.

Discussion of Baseline IEUBK Model Results

The results of the Baseline IEUBK Model applications suggest that there are potentially three different exposure situations ongoing in the Basin with respect to the residential soil and dust lead. East of the BHSS, the Baseline Box Model is a better predictor of observed blood lead levels. In these areas, the EPA Default Baseline model significantly over-predicts both observed concentrations and the percent of children to experience excess absorption. Immediately east of the BHSS in Osburn, the Side Gulches and Silverton, the Baseline Box Model fairly-well describes both observed mean blood lead levels and the percent of children exceeding the health criteria.

West of the BHSS and particularly in the Lower Basin the Box Model is ineffective, under-predicting both mean blood lead levels and percent exceedance. The EPA Default Model describes mean blood lead levels fairly well, but fails to capture the percent of children to exceed health criterion.

The magnitude of the variance in observed population blood lead levels, particularly in the Lower Basin, suggests a large variation in exposure. This is especially true relative to the Baseline intake estimates. A small number of children are exhibiting much greater blood lead levels than expected under any scenario from the Baseline intakes. Potential sources of these additional exposures are addressed in the incremental exposure analysis.

6.6.2 Resident Children's Incremental Blood Lead Levels

Recreational Exposures Blood Lead Increments

Incremental lead intake rates associated with children's recreational activities were developed in Section 6.5. Tables 6-32 through 6-41 show incremental intake rates associated with potential media concentrations for soils in upland park areas, neighborhood sediments and surface waters, public beaches, and waste piles. Tables 6-35 through 6-41 show typical percentile concentrations for these media for each geographic subarea and developed specific intake estimates using CT ingestion rates and CT (50th percentile) and RME (95th percentile) media concentrations for those areas.

Table 6-51a develops estimates of blood lead increments associated with the CT recreational intake estimates for upland parks from Table 6-35. This is accomplished by adding the estimated annual average intake in µg/day to the baseline model for each subarea through the *Other Source* option of the IEUBK Model. For example, in Table 6-51a, the 50th percentile recreational intake estimate for upland park areas in Mullan is 7 µg/day. Entering this rate through the *Other Source* route in the IEUBK EPA Default baseline model (Table 6-47a), results in an estimated blood lead level of 9.8 µg/dl for 0-84 month old children. This compares to the baseline estimate of 9.3 µg/dl from Table 6-47a, or a 0.5 µg/dl increase. This represents about a 5% predicted increase in mean blood lead level associated with the 7% increase in intake for the CT upland park media concentration of 1189 mg/kg from Table 6-35a.

Table 6-51b shows the addition of the 95th percentile recreational intake increment. This represents a child playing at the most contaminated upland park CUA (e.g., 3270 mg/kg from Table 6-35a for Mullan). This 20% increment in intake results in a mean blood lead estimate of 10.6 µg/dl, an increment of 1.3 µg/dl, or a 14% increase in blood lead level.

Tables 6-51a-b also show the estimated percent of children to exceed 10 µg/dl if they were to engage in these play activities at the upland park locations. For the Mullan example, the EPA Default Model predicts that 45% of 0-84 month old children will exceed 10 µg/dl due to the baseline exposure (See Table 6-47a). This value can be interpreted as the probability that a child would experience an excessive blood lead level associated with baseline exposures in Mullan according to EPA Default Model estimates. Tables 6-51a-b, respectively, show that this probability increases to 45% for the CT exposure and 53% for the RME.

Tables 6-51a-b also show corresponding estimates developed using the Box Model to predict baseline and incremental blood lead levels. Similar results are shown for neighborhood streams and sediments in Tables 6-52a-b, public beaches in Tables 6-53a-b, and waste piles in Tables 6-54a-b.

Discussion of Children's Recreational Incremental IEUBK Model Results

Figures 6-19a-h summarize the incremental blood lead results for each geographic area. These are discussed in the following four sub-sections. *Upland park activities* refer to general recreational practices in contact with soils in non-water related activities. Swimming and intense contact with waters and sediments are discussed in the *public beaches* section. Wading and stream exploration-type activities in the general residential area near homes are discussed under *neighborhood sediments and surface water*. Contact with *waste piles* is discussed in the final sub-section below.

Upland Park Activities. Figures 6-19a-h show the observed mean and estimated baseline and baseline plus incremental blood lead levels associated with upland park recreational activities for each geographic subarea. These results suggest that there are relatively modest potential increases in blood lead levels associated with typical upland park activities in the upper Basin in comparison to baseline levels. For the 50^{th} percentile (or CT) CUA soil concentration typical incremental intake and blood lead increases are less than 10% of baseline east of the BHSS. For the RME, however, there are substantial increases projected for extremely contaminated play areas in the upper Basin. No upland park CUAs were identified for the Burke/Nine Mile area. Recreational activities for this subarea are discussed under neighborhood sediments and surface water and waste piles.

West of the BHSS, conversely, there are substantial potential increments for these activities in typical recreational activities in the Kingston and Lower Basin areas relative to baseline estimates. Inclusion of potential recreational intakes in these areas results in near 50% increases above baseline intake rates and projected blood lead levels.

Neighborhood Sediments and Surface Water. Figures 6-19a-h show the observed mean and estimated baseline and incremental blood lead levels associated with neighborhood sediments and surface water recreational activities for each geographic area. For the typical or CT media concentration levels, minimal intake and blood lead increments are projected for contact with local sediments and stream water in Mullan and the Lower Basin. In this case, exposures in the Lower Basin are limited to the Pine Creek area. Most water contact exposures for the Lower Basin are discussed as public beach activities. Near 10% increases are predicted in both intake and blood lead for the remainder of the upper Basin, with expected levels somewhat higher in Burke/Nine Mile. For the RME, however, the most contaminated streams result in 20% to 35% increases in the Wallace to BHSS reach, a 50% increase in Mullan, and nearly a tripling of baseline intake in Burke/Nine Mile (271% increase).

Public Beaches. Figures 6-19a-h show for each geographic area the observed mean and estimated baseline and incremental blood lead levels associated with public beach recreational activities. Public swimming areas are assessed throughout the Basin and are not subdivided by geographic subarea. However, for this analysis the incremental exposure is added to baseline for each subarea. Substantial incremental intake and estimated blood lead increments are predicted for sediment and disturbed surface water ingestion at public beaches throughout the upper and Lower Basin for typical or CT concentrations. Estimated incremental blood lead levels range from 13.2 µg/dl for Wallace children to 6.6 µg/dl in the Lower Basin. Respectively, these are 33% and 69%

potential increases in blood lead level associated with public beach activities at 50th percentile concentrations. Engaging in these activites at RME (95th percentile) sites can result in more than doubling annual intake rates and substantial blood lead increases for children throughout the Basin.

Waste Piles. Figures 6-19a-h show for each geographic area the observed mean and estimated baseline and incremental blood lead levels associated with play on waste piles in the upper Basin areas of Mullan and Burke/Nine Mile. For the 50th percentile (CT) concentrations incremental exposures are minimal in Mullan and about 10% increase over baseline in Burke/Nine Mile. At the RME (95th percentile) concentration, a 14% increase is projected for Mullan and a near doubling of total intake is predicted for Burke/Nine Mile.

Summary of Children's Recreational Incremental Exposures. Potentially significant recreational exposures are noted for certain activities in particular areas of the Basin. Upland park type recreation can result in significant exposures in the more contaminated areas of the upper Basin and throughout the areas west of the BHSS. Potential recreational exposures in the Lower Basin are more significant because of both higher soil concentrations and lower baseline residential exposures. This can result in higher dose-response rates to incremental exposures at lower blood lead levels. This is a possible explanation for the higher than predicted blood lead levels observed among Lower Basin children.

Additionally, swimming and water sport activities that could result in ingestion of disturbed sediment laden surface water can result in substantial increases in intake and lead absorption. Potential exposures are of particular concern to neighborhood stream sediments in Burke/Nine Mile, and at public swimming areas in the Side Gulches and the Lower Basin.

Incremental Blood Lead Levels Associated with Local Foodstuff

Homegrown Produce. Tables 6-55a-b show estimated CT and RME blood lead levels, respectively, associated with consuming local produce. Potentially significant increases in blood lead levels could result from consumption of home grown vegetables. Increased intake from foodstuff can result in higher blood lead levels due to the high bioavailability of dietary lead.

Sport Fishery. Tables 6-56a-b show similar results for local fish consumption. Figures 6-19e-h show baseline and estimated incremental blood lead levels by geographic area including, local foodstuff.

6.6.3 Adult Model Blood Lead Estimates

Adult Occupational Blood Lead Level Estimates

Tables 6-57 and 6-58 show the USEPA Adult Model for lead applications for occupational Preliminary Remediation Goals (PRGs) for the parameters and intakes shown in Tables 6-27 through 6-30, respectively, for CT and RME scenarios. The EPA Adult Model does not calculate blood lead levels per se, but determines the concentration value for soils that would result in an upper confidence limit (95^{th} percentile) blood lead level of 10 µg/dl for women of child-bearing age. There is no provision for site-specific modification to the Adult Blood Lead Model. The results suggest that for CT or medium intensive soil contact occupations 95^{th} percentile blood lead levels would exceed 10 upper confidence limit at soil concentrations ranging from 2800 mg/kg to 4500 mg/kg. For intensively exposed or RME occupational activities, corresponding values range from 300 mg/kg to 500 mg/kg.

Adult Recreational Blood Lead Level Estimates

Tables 6-59a-b and 6-60a-b show CT and RME values with PRG calculations for upland park and CUA recreational activities for adults. These results predict that the 95^{th} percentile adult blood lead level of 10 upper confidence limit or greater would occur with intensive (RME) soil contact at levels of 3700 mg/kg to 6400 mg/kg lead. For recreational activities with medium intensity contact with upland park soils, typical concentrations observed in the Basin would not result in blood lead levels greater than 10 upper confidence limit.

For intense soil contact recreational practices such as dirt biking, beach activities, four-wheeling, gardening, landscaping, etc., that involve deliberate and continued contact with soils, 95^{th} percentile blood lead estimates exceed 10 µg/dl at concentrations ranging from 3700 mg/kg to 6400 mg/kg lead. These values generally represent the 90^{th} to 95^{th} percentile concentrations in upper Basin recreational areas and 50^{th} to 95^{th} percentiles among Lower Basin CUAs.

6.6.4 Native American Blood Lead Levels

Blood lead levels were not estimated for either the traditional or current subsistence scenarios because estimated lead intake levels ranged from 300-1000 µg/day. These high rates coupled with cultural-specific dietary and behavioral considerations precluded estimating all RME and CT scenarios. Estimated lead intake rates for these scenarios are sufficiently high to invalidate current blood lead models. Predictions for blood lead levels associated with subsistence activities in the floodplain of the Lower Basin would exceed any current health criteria for children or adults in either scenario.

6.7 RISK CHARACTERIZATION

6.7.1 Overview and Summary

The risk of lead poisoning among adults and children has been assessed in several ways in the preceding sections. Observed blood lead levels among the population indicate significant incidence of high blood lead levels among children in the Basin. Quantitative site-specific analysis of paired blood and environmental variables indicate excess absorption is associated with a combination of contaminated soils, house dust and paint sources. Lead intake estimates developed for various pathways indicate potentially significant rates associated with both baseline (everyday home life common to the entire population) and incremental exposures (certain activities practiced by part of the population).

Predictions of blood lead levels and percent of resident children to experience excess absorption was accomplished with two IEUBK Models, both run in the community and batch modes. The EPA Default version predicts higher blood lead levels and percent of children to exceed 10 µg/dl than the site-specific model employed at the neighboring BHSS. Both models predict excess absorption rates associated with baseline residential exposures for the upper Basin east of Silverton. The models provide conflicting results in Osburn and the Side Gulches. The EPA Default model suggests greater than 5% above the 10 µg/dl criteria, and the Box Model projects 2% to 5% exceedance. Neither model, ***using baseline residential exposures***, predicts the degree of excessive absorption observed in Kingston or the Lower Basin. Both models predict potentially significant incremental blood lead levels associated with particular recreational activities in contaminated areas, and consumption of local foodstuff. These incremental exposures may explain the higher than expected blood lead levels observed in the Lower Basin.

Observed blood lead levels among adults are significantly lower, particularly among reproductive aged females. Older individuals tend to have higher blood lead levels in the adult population. Intake and Adult Model blood lead predictions indicate potentially significant risks associated with occupational and recreational activities in certain areas, and consumption of local foodstuff.

Evaluation of potential Native American lifestyle practices in the Lower Basin indicate potentially severe lead intake rates for both children and adults in either the traditional existence or current subsistence scenarios. Both non-food (soil, sediment, and water), and fish and riparian foodstuff exposure routes result in unacceptably high lead intake levels.

6.7.2 Indices of Lead Health Risk

The risks associated with blood lead levels are characterized by comparison to the CDC criteria: excessive prevalence of blood lead levels in the 10-14 µg/dl range are indicative of excess exposure to the individual (Class IIA); levels of 15-19 µg/dl are indicative of excessive lead absorption and require education and nutritional intervention and more frequent screening (Class IIB); levels of 20-44 µg/dl require medical and environmental intervention and perhaps chelation (Class III); levels of 45 µg/dl and higher (45-69) require environmental and medical intervention with chelation therapy (Class IV). Children with blood lead levels at or above 70 µg/dl require hospitalization and chelation therapy, along with immediate environmental management (Class V).

Current USEPA policy seeks actions that limit exposure to soil lead levels such that a typical (or hypothetical) child or group of similarly exposed children would have an estimated risk of no more than 5% exceeding a 10 upper confidence limit blood lead level. The USEPA also recommends the use of the individual residence as the primary exposure unit of concern and that the IEUBK Model be used as the primary tool to estimate risk. This policy effectively requires that the probability of the typical 0-84 month old child at any residence experiencing a blood lead level of 10 µg/dl or greater be less than 5%. This differs from the RAO adopted at the adjacent BHSS that requires that no more than 5% of the community wide population of nine month to nine year old children have levels of 10 µg/dl or greater and that less than 1% of children have levels of 15 µg/dl or greater. Comparisons of predicted blood lead levels to both criteria are accomplished below.

6.7.3 Observed Blood Lead Levels

The highest toxicity rates among nine month through nine year old children are observed in Burke/Nine Mile at 21% exceeding 10 µg/dl, 13% exceeding 15 µg/dl and 4% with levels of 20 µg/dl or greater. The Lower Basin subarea showed the next highest toxicity rate with 18% exceeding 10 µg/dl and 5% greater than the 15 µg/dl criteria. No children were in the 20 µg/dl range in the Lower Basin. Wallace, Mullan and Silverton, respectively, showed 13%, 11% and 8% of children with levels of 10 µg/dl, or greater. From 4% to 5% of children tested in Wallace and Silverton exhibited blood lead levels exceeding the 15 µg/dl criteria and 1% to 3% exceeded 20 µg/dl, respectively. Osburn and the Side Gulches area both showed 4% of children exceeding 10 µg/dl and only one child (in the Side Gulches) in four years exceeded 15 µg/dl. Kingston showed 11% greater than or equal to 10 µg/dl and 7% exceeded the 15 µg/dl criteria.

The highest blood lead levels are observed in the youngest age groups. One and two year old children have arithmetic mean blood lead levels of 7.0 µg/dl and 8.0 µg/dl , respectively, and geometric mean concentrations of 6.2 µg/dl to 6.3 µg/dl. Geometric mean levels then decrease with age from 5.2 µg/dl at age 3 to 3.0 µg/dl at age 8.

The percent of children to exceed critical toxicity levels differs markedly with age. In the lowest age groups, 9 months to 36 months, 19% to 26% exceed 10 µg/dl. The rate is highest in 2 year old children with 17% of this group exceeding 15 µg/dl. For four year old children 12% exceed 10 µg/dl and 5% exceed 15 µg/dl. In older children, the percent to exceed 10 µg/dl ranges from 5% to 8%, and 1% to 3% exceed 15 µg/dl.

Follow-up investigations were completed by the local health department for 50 of 58 children whose blood lead levels exceeded 10 µg/dl. Twenty-six investigations involving 21 individual children were for observed blood lead levels exceeding 15 µg/dl. Risk profiles indicate excess absorption associated with high soil and dust concentrations at homes in the Burke/Nine Mile subarea. Older children’s risk profiles in this area indicate recreational exposures in neighborhood areas contaminated by tailings. High blood lead levels in Wallace are indicated in younger children and are possibly associated with paint and remodeling problems, high soil lead levels in play areas, and dusty or difficult to clean homes. Both Mullan and Osburn had no children greater than the 15 µg/dl blood lead criteria and children's blood lead levels in the 10-14 µg/dl range were associated with high residential soil and dust concentrations or play in contaminated areas. West of the BHSS, excess absorption was associated with either homes that had been flooded or extended recreational activities in the river or lateral lake areas of the Lower Basin.

6.7.4 Site-specific Analysis of Paired Blood Lead and Environmental Source Observations

Site-specific quantitative analysis of the relationship between blood lead levels and environmental variables indicate that contaminated soils, house dust and lead based paint are all related to excess absorption. The overall results suggest complex exposure pathways, with lead absorption levels most related to dust lead loading in the home, followed by independent effects of yard soil lead, interior paint lead condition and exterior paint lead content. The dust lead pathway is most influenced by outdoor soils, augmented by paint contributions in older homes, especially those in poor condition. The overall effect is exacerbated by extremely dusty conditions in Burke/Nine Mile and to a lesser extent in Wallace. The Lower Basin is a notable exception. High blood lead levels are observed, although little problem is indicated with respect to dustiness or dust lead concentrations in the Lower Basin.

Quantitative models relating blood lead levels to soil, house dust, and paint lead levels and house dust levels to soil and paint sources were developed. These are used below to quantify baseline exposures and project risk reductions that might be achieved through source modifications.

6.7.5 Predicted Blood Lead Levels

The USEPA emphasizes the use of the IEUBK Model for estimating risks for childhood lead exposure from a number of sources, such as soils, dust, air, water, and other sources to predict blood lead levels in children 6 months to 84 months old. EPA recommends that the IEUBK Model be used as the primary tool to generate risk-based soil cleanup levels at lead sites for current or future residential land use. Response actions can be taken using IEUBK Model predictions alone; blood lead studies are not required.

Current USEPA policy also recommends that risk assessments use the individual residence as the primary exposure unit of concern. This does not mean that a risk assessment should be conducted for every yard, rather that the soil lead contamination data from yards and other residential media (for example, interior dust and drinking water) should be input into the IEUBK Model to provide a preliminary remediation goal (PRG) for the residential setting. When applicable, potential exposure to accessible site-related lead sources outside the residential setting should also be evaluated to understand how these other potential exposures contribute to the overall risk to children, and to suggest appropriate cleanup measures for those areas (USEPA 1998f).

This policy has been addressed in this assessment. Lead health risks in the residential setting are projected through ***baseline residential exposures*** and those outside the residential setting are assessed through ***incremental exposures***.

Residential Baseline Blood Lead Level Predictions

Residential baseline (everyday home life) blood lead predictions were accomplished using four different applications of the IEUBK Model. Both the EPA Default Model (using national assumptions for soil and dust ingestion rates and bioavailability) and the Box Model derived specifically for the BHSS were employed. Both models were applied in both the community and batch modes. The results suggest that there are potentially three different exposure situations ongoing in the Basin with respect to the residential soil and dust lead.

East of Wallace, the baseline Box Model is a better predictor of observed mean blood lead levels. In these areas, the EPA Default baseline model significantly over-predicts both observed concentrations and the percent of children to experience excess absorption. In the community mode, both models predict more than 5% of 0-84 month old children will exceed the 10 µg/dl criteria in Mullan, Wallace, and Burke/Nine Mile. The EPA Default Model predicts 40% to 50% exceedance in these areas, the Box Model predicts 15% to 20% above the criteria. Observed exceedance in these areas ranged from 10% to 22%.

Immediately east of the BHSS in Osburn, the Side Gulches and Silverton, the Baseline Box Model fairly-well describes both observed mean blood lead levels and the percent of children exceeding the health criteria. Observed exceedance of the 10 µg/dl criteria for 0-84 month old children ranged from 5% to 11% in this reach. The EPA Default Model predicts 15% to 21% exceedance ***associated with baseline residential exposures*** for these areas, as opposed to the Box Model 3% to 5% projection.

West of the BHSS and particularly in the Lower Basin the Box Model is ineffective, under-predicting both mean blood lead levels and percent exceedance. The EPA Default Model fairly-well describes mean blood lead levels, but fails to capture the percent of children to exceed health criteria. Both the EPA Default and Box Models failed to predict these high blood lead levels. The community mode estimates for Kingston (14% observed greater than 10 µg/dl) were 9% and 2%, respectively, for the EPA Default and Box models. For the Lower Basin (25% observed greater than 10 µg/dl), the respective community mode predictions were 2% and 0%. Batch mode estimates for Kingston were 10% for the EPA Default Model and 2% for the Box Model. Batch mode estimates for the Lower Basin were better, 20% and 13%, respectively, but also under-predicted the 32% observed.

There are several possible factors that could contribute to the difference in exposures and blood lead levels among these areas of the Basin. There could be physical and chemical differences in the soil and dust contaminants. Differences in chemical form, particle size and matrix effects could result in different physical accessability and bioavailability to children. These differences could be attributable to the original source of the lead from mine, mill or smelter wastes, or from the degree of weathering and secondary mineralization that has occurred while in the environment.

The degree of dustiness and snow cover in these communities could be a factor, as the larger communities have curbs and gutters and other infrastructure that is not available in the smaller villages. The size of yards, use of lead paint, age of the communities and proximity to industrial or transportation sources could all impact this relationship. The habits and behavior of children, particularly as they move about neighborhoods and select favorite play areas and activities may present important differences in the larger cities, small residential areas or rural homes.

Generally, the Batch mode more accurately reflects variance in exposures and is a better predictor than the community mode of the IEUBK Model. The EPA Default version of the IEUBK Model Batch Mode application predicts a greater than 5% exceedance of the 10 µg/dl health criteria, ***associated with baseline residential exposures***, for all geographic areas. The Box Model predicts exceedance greater than 5% for Mullan, Burke/Nine Mile, Wallace, Silverton and the Lower Basin. The areas adjoining the BHSS including Kingston, Osburn and the Side Gulches are projected at less than 5% exceedance for baseline residential exposures by the Box Model.

Incremental Exposure Blood Lead Predictions

Potentially significant recreational exposures are noted for certain activities in particular areas of the Basin. Upland park type recreation can result in significant exposures in the more contaminated areas of the upper Basin and throughout the areas west of the BHSS. Potential recreational exposures in the Lower Basin are more significant because of both higher soil concentrations and lower baseline residential exposures. This can result in higher dose response rates to incremental exposures at lower blood lead levels. This is a possible explanation for the higher than predicted blood lead levels observed among Lower Basin children.

Additionally, swimming and water sport activities that could result in ingestion of disturbed sediment-laden surface water can result in substantial increases in intake and lead absorption. Potential exposures are of particular concern to neighborhood stream sediments in Burke/Nine Mile, and at public swimming areas in the Side Gulches and the Lower Basin.

Potentially significant increases in blood lead levels could also result from consumption of home grown vegetables. Increased intake from foodstuff can result in higher blood lead levels due to the high bioavailability of dietary lead.

Adult Resident Population Blood Lead Predictions

Occupational. Adult blood lead model estimates were developed for medium intensity soil contact occupations or jobs involving periodic exposure to soil sources, such as public property maintenance, typical construction workers, or laborers. These results suggest that exposures to soils ranging in lead concentration from 2800 mg/kg to 4500 mg/kg could result in more than a 5% probability of blood lead greater than 10 upper confidence limit. Few soil concentrations in this range are observed in residential areas of the Basin. In upland park CUAs these values correspond to the 90^{th} to 95^{th} percentile of sites. In the Lower Basin floodplain 50% to 95% of soils exceed these levels.

Intensive or RME exposure refers to individuals whose employment specifically involves exposures to soils such as landscapers; farmers and agricultural workers; remediation workers; construction workers routinely involved in excavation, demolition, or site development; or utility or road workers. Mineral industry workers are excluded from the occupational scenario, as exposure to lead is specifically regulated by occupational health authorities. Although individuals working in the mining industry are not evaluated in this HHRA for lead exposure in the workplace, they are considered in the residential scenario. For these workers, soils near 500 mg/kg could result in more than a 5% probability of having a blood lead level greater than 10 upper confidence limit.

Recreational. For typical adult recreational activities, less than 5% probability of exceeding 10 upper confidence limit is predicted for all recreational area soil concentrations observed in the Basin. For intense soil contact recreational practices such as dirt biking, beach activities, four-wheeling, gardening, landscaping, etc., that involve deliberate and continued contact with soils, 95th percentile blood lead estimates exceed 10 upper confidence limit at concentrations ranging from 3700 mg/kg to 6400 mg/kg lead. These values generally represent the 90th to 95th percentile concentrations in upper Basin recreational areas and 50th to 95th percentiles among Lower Basin CUAs.

Native American Blood Lead Levels

Blood lead levels were not predicted for either the traditional or current subsistence scenarios because extremely high intake rates coupled with cultural-specific dietary and behavioral considerations invalidate current blood lead models. Nevertheless, projected intake rates are sufficiently high to suggest that blood lead levels associated with subsistence activities in the floodplain of the Lower Basin would exceed any current health criteria for children or adults in either scenario.

It is important to note that the high lead intake rates are associated with several media. Soil and sediment intakes, fish fillet and peeled water potato, and ingestion of disturbed surface water during swimming and bathing activities would each individually result in excessive lead intake. Consumption of whole fish from the Spokane River or un-peeled water potatoes from the Lower Basin would result in especially dangerous intake levels.

6.7.6 Potential Lead Health Risk Reduction Strategies

These overall results suggest complex pathways of exposure are ongoing in the Basin. Resident children's blood lead levels are most related to dust lead loading in the home, followed by independent effects of yard soil lead, paint lead condition, and exterior lead paint content. The dust lead pathway is most influenced by outdoor soils, but is augmented by paint contributions particularly in older homes in poor condition. The overall effect is exacerbated by dusty conditions in Burke/Nine Mile and to a lesser extent in Wallace. Significantly, less problems are noted with respect to dustiness or dust concentrations in the Lower Basin. West of the BHSS, excess absorption was associated with either homes that had been flooded or extended recreational activities in the river or lateral lake areas.

Potentially significant recreational exposures are noted for certain activities in particular areas of the Basin and from consumption of home grown vegetables. Excessive occupational exposures could occur with particular unprotected jobs in highly contaminated areas. Subsistence Native American practices in the Lower Basin would be dangerous, particularly if whole fish or un-peeled water potatoes made up a substantial portion of the diet.

These pathways suggest an integrated approach to risk reduction may be advised. Baseline residential exposures could possibly be reduced through cleanup of excessive soil contamination coupled with paint stabilization to simultaneously reduce direct exposure to these media and house dust lead concentrations. Targeted cleanups of recreational areas, coupled with access limitations or appropriate warnings, could be used to prevent excessive incremental exposures. Provision of clean gardening media could reduce incremental exposure to local produce. Worker safety protocols could be developed to protect adults while employed in contaminated soil related jobs. Native Americans should continue to refrain from food harvest and subsistence activities in the Lower Basin until substantial improvements are made. In the interim, individual children's problems could be addressed by removal actions and continuing and enhancing current health intervention activities until final remedial determinations are completed.

For the resident population, children's baseline blood lead levels are likely to be the determining factor in establishing media-specific remediation goals or concentration action levels. The baseline blood lead levels then become a critical determinant in developing required risk reduction strategies for incremental, or away from home, activities. As a result, it is possible to discuss preliminary cleanup levels for risk manager's consideration for children's baseline residential exposures and adult occupational and recreational activities.

However, discussion and development of candidate action levels for children's incremental recreational activities and fish and local produce consumption cannot be addressed in this document. Appropriate risk reduction methods and action levels will have to evaluated by risk managers after fundamental approaches to reducing baseline blood lead levels have been identified.

Resident Childhood Population Baseline Risk Reduction

Community Mode IEUBK Model Blood Lead Projections for Various Cleanup Action Levels. The community mode of the IEUBK model was used to conduct an abbreviated sensitivity analysis regarding potential residential soil cleanup remedies. Select input parameters were varied in the IEUBK to evaluate those most likely to influence outcome blood lead levels in soil lead reduction scenarios. Only soil and dust concentration variables were modified in this analysis. The soil and dust partition and bioavailability assumptions inherent in the EPA Default and Box Model applications were retained in these analyses. Outcome dust lead concentrations resulting from soil and paint lead remediation efforts were found to be the most important determinant of post-remedial blood lead levels. The key to evaluating this strategy is estimating the effect any soil or paint remediation efforts will have on dust lead concentrations. Figures 6-20a-b demonstrate, respectively for Wallace and the Lower Basin, the sensitivity of the predicted percent of 0-84 month old children to exceed the 10 µg/dl health criteria for various soil and dust lead concentration reduction scenarios. Tables 2 and 3 and Figures 1 through 3 in Appendix R show results for all subareas in tabular and graphic format.

Figures 6-20a-b show results for a remediation strategy addressing home yards with soil lead concentrations exceeding action levels varying from 2000 mg/kg to 400 mg/kg. In each case it is assumed that soils exceeding the action level are replaced with soils of less than 100 mg/kg. The value of the resulting community mean lead level is then recalculated using these substitute values for remediated yards. Tables 2 and 3 in Appendix R show the resulting community mean soil lead level. This value is input to the community mode IEUBK Model and outcome blood lead levels are estimated for both the EPA Default and the Box Model.

Two potential effects representing the practical bounds, or most pessimistic and most optimistic outcomes, of any dust lead reduction are assessed in Figures 6-20a-b. Those bounds are i) dust lead levels remain unchanged, or ii) dust lead levels reduce to the geometric mean soil lead concentration. Examination of the results in Figure 6-20a lead to some main conclusions. The first finding is that outcome dust lead levels in the upper Basin are critical determinants of the efficacy of any cleanup strategy. Substantial reduction of house dust lead levels in the upper Basin will be necessary under any scenario to achieve acceptable blood lead levels.

Figure 6-20a shows that if Wallace dust lead levels remain unchanged, the 5% exceedance goal is unattainable in the EPA Default analysis and only marginally attainable at cleanup limits of 600 mg/kg, or less, under the Box Model assumptions. Under the most optimistic assumption that dust concentrations decrease to concurrent soil lead projections, a 5% exceedance of 10 µg/dl is achieved at the 1500 mg/kg level for the Box Model and 1000 mg/kg for the EPA Default Model.

In the Lower Basin (shown in Figure 6-20b), and to a lesser extent in the Kingston subarea, yard soil and house dust lead concentration reductions are unlikely to be effective in reducing observed high blood lead levels, unless these homes are located within the floodplain. Residential soil and dust lead concentrations in these areas are generally low and baseline intake rates do not suggest an absorption problem. For these areas, excepting some individual situations, development of strategies addressing incremental exposures outside the home environment are more likely to be effective in reducing risk of lead poisoning. Because residential soil and house dust concentrations are generally low in the Lower Basin, it is likely that children residing on properties located outside of the floodplain are receiving much of their exposure outside of the home, including recreational areas.

Estimating Post-remedial Soil and Dust Lead Concentrations. In assessing potential action levels for soils and dusts, there are substantial differences between the EPA Default and Box Model projections. Use of the EPA Default model would require substantially lower action levels than the Box Model projections. The EPA Default Model predicts future levels based on nationally derived assumptions of soil/dust intake and typical bioavailability. The Box Model assumes that past relationships between environmental lead and blood lead will be predictive of future exposures and behavior patterns. Although calibration of the lead model with blood lead data can accurately describe past relationships between environmental and blood lead levels, its predictive value depends on sustaining patterns of behavior and levels of awareness that modify levels of exposure. Behavior modification has not yet been proven effective as a long-term approach to preventing lead hazards.

In either model format, the key to evaluating this strategy is estimating the effect any soil or paint remediation efforts will have on dust lead concentration. The site-specific analysis can be used to preliminarily assess the efficacy of any strategy adopted to reduce dust lead levels. The site-specific analysis suggests that blood lead levels are highly dependent on dust lead loading rates, yard soil contamination levels, and paint lead, particularly in poorly maintained housing. Dust lead loading rates, in turn, are dependent on both dust loading or dustiness in a community and the lead content of that dust. Outdoor soils both in the yard and the community are the primary determinant in dust mat lead concentrations augmented by interior paint lead levels, again in poor quality housing.

The quantitative relationships developed in the site-specific analysis can be used to assist in predicting the effects of risk reduction strategies. Figures 6-21a-h show, for each subarea, projected community soil, dust mat and vacuum bag dust lead levels. The latter values are predicted by substitution of the appropriate soil concentrations into the regression model equations developed in Tables 6-22c and 6-23. This was a two step process, first estimating mat lead concentration in equation 6-22c from yard and community mean soil lead levels assuming good minimum paint condition. The resultant mat concentration estimate was then substituted with soil and mean, or typical, interior paint concentration in equation 6-23 to provide an essential vacuum bag dust lead concentration. Both projections assume paint stabilization has been implemented in the poorest quality housing.

Batch Mode IEUBK Model Blood Lead Projections for Various Cleanup Action Levels. IEUBK Model batch mode estimates are made using the entire 994 home data base assembled for the Basin. Mean blood lead levels are estimated for 12 through 84 month old children at every home in the Basin using the observed yard soil lead concentration and estimated dust lead levels shown in Figures 6-21a-h. Progressive remediation schemes are evaluated by reducing all yard soil concentrations greater than the suggested action level to 100 mg/kg lead and recalculating the community mean soil lead and dust lead values. This was accomplished at potential action levels of 2000 mg/kg, 1500 mg/kg, 1000 mg/kg, 800 mg/kg, 600 mg/kg and 400 mg/kg.

Tables 6-61a-f and 6-62a-f summarize the results for the EPA Default and Box Model versions, respectively. Figures 6-22a-h show the results for both models for both community wide and individual risks for 0 through 84 month children to exceed 10 µg/dl and 15 µg/dl health criteria. For example, for the 1000 mg/kg action level in Figure 6-22h, the community wide probability to exceed 10 µg/dl is 3% for the EPA Default estimate and 0% for the Box Model in the Lower Basin. In Wallace (Figure 6-22c) the estimate is 21% for the EPA Default Model and 5% for the Box model. Estimated percentages of children to exceed 15 µg/dl are found in the inset to these figures. For the 1000 mg/kg action level for Wallace, 7% are expected to exceed 15 µg/dl for the EPA Default Model, and 1% are expected for the Box Model.

Current USEPA policy requires that the probability of the typical 0-84 month old child at any residence experiencing a blood lead level of 10 µg/dl or greater, be less than 5%. Figures 6-22a-h also show (in parentheses) the maximum individual risk for 0-84 month old children associated with candidate action levels. These estimates are developed using the action level for the yard soil lead concentration and the estimated community mean dust concentration. As a result, there may be some underestimation of blood lead due to the dust lead level. The maximum individual probability of exceeding 10 µg/dl for the 1000 mg/kg action level for the Lower Basin is 38% by the EPA Default Model, and 7% by the Box Model. For Wallace, corresponding values are 46% and 12%, respectively. For the 1000 mg/kg action level example above the most exposed children in the Lower Basin would have a 14% probability of exceeding 15 µg/dl in the Lower Basin according to the EPA Default Model and a 1% chance by the Box Model. Corresponding probabilities for Wallace are 19% and 2%.

There are two major considerations in assessing these results. First, the risk of exceeding the health criteria projected in this analysis only accounts for baseline (or home residential) exposures after paint stabilization. Consequently, there is no safety margin allowing for incremental exposures that might occur in addition to home exposure. Second, current USEPA policy and the RAOs applied at the BHSS require consideration of individual risks for those children left at the highest exposure levels.

The disparity in risk allocation across a post-remedial community results from the nature of a yard soil cleanup implemented on a yard-by-yard basis. Remediated yards have levels near background (40 mg/kg to 100 mg/kg lead), while other children are exposed to concentrations 4 to 50 times greater depending on the action level. At the BHSS, this disparity was addressed through the 15 µg/dl RAO. The 1000 mg/kg action level at the BHSS was addressed in the RAO requiring that less than 1% of children exceed the 15 µg/dl criteria. The cleanup action level necessary to meet the site wide goal of having less than 5% of the children exceeding 10 µg/dl at the BHSS was approximately 1500 mg/kg. However, this level was rejected in favor of the more protective 15 µg/dl RAO. Maximum post-remedial individual risks at the BHSS are estimated at between 10% and 15% for the 10 µg/dl health criteria and from 1% to 2% for the 15 µg/dl RAO. Comparable risk levels could be achieved in the Basin with a 400-600 mg/kg action level by the EPA Default model or an 800-1000 mg/kg action level by the Box Model. The acceptable level of risk to individuals will likely be a critical determinant in developing risk management alternatives for the Basin.

Individual risks for those children in homes with yard soil lead concentrations near the action level are shown in Tables 6-61a-f through 6-62a-f, for each of the candidate action levels. For example, for the 1000 mg/kg action level in Table 6-61c, the columns headed *Homes 800-1000 mg/kg* show the risk of exceeding 10 µg/dl ranges from 36% to 46% for children living in these homes according to the EPA Default Model. The corresponding value for the Box Model in Table 6-62c is 7% to 12%.

These tables also indicate the number and percent of the homes sampled in each subareas, the number and percent of those homes that would require remediation under the 1000 mg/kg action level, and how many homes are in the 800 mg/kg to 1000 mg/kg range in each geographic subarea. For example, 42 (or 38%) homes in Wallace were above the 1000 mg/kg action level and eighteen (or 16%) additional homes are in the 800 mg/kg to 1000 mg/kg range.

The subsequent remediation Table 6-61d shows the outcome if those homes in the 800 mg/kg to 1000 mg/kg range were remediated. Overall community wide risk would remain about the same in

Kingston and the Lower Basin, but would drop from 21% to 14% in Wallace, with intermediate drops in other areas. Those at highest risk are now in the 600 mg/kg to 800 mg/kg range and have about a 10% lower probability of experiencing a high blood lead level, than those in the previous table.

For the EPA Default Model in the batch mode, 5% probabilities are not achieved even at the 400 mg/kg cleanup level. At an action level of 400 mg/kg, probabilities of exceeding 10 µg/dl remain at 6% for several areas.

Results for the Box Model shown in Tables 6-62a-f are much different. Community wide probabilities of exceeding 10 µg/dl are indicated at the 2000 µg/dl action level in Kingston and the Lower Basin, and at the 1500 mg/kg level in Silverton, the Side Gulches and Osburn. All areas project less than 5% of children greater than or equal to 10 µg/dl at the 1000 mg/kg action level.

For the 1000 mg/kg Box Model action level scenario (Table 6-62), risks to children in the 800 mg/kg to 1000 mg/kg yard soil lead concentration range are from 7% to 12%. The probability of exceeding 15 µg/dl ranges from 1% to 2% for these children. These risk probabilities are similar to the RAOs for the BHSS. Under this cleanup scenario approximately 33% to 43% of homes in areas east of Wallace, and 8% to 13% of homes in the remainder of the Basin would require remediation.

For the 800 mg/kg Box Model action level from 40% to 55% of homes east of Wallace and 13% to 17% of homes in the remainder of the Basin would require remediation. The probability of exceeding 10 µg/dl for the highest individuals drops to 3% to 6% with less than 1% projected to exceed 15 µg/dl. Figures 6-22a-h summarize these results. The values in parentheses show the average individual probability of exceeding 10 µg/dl for children living in homes with the highest post-remedial soil concentrations. The inset table shows the community wide and individual probability of exceeding the 15 µg/dl health criteria.

Incremental Exposure Risk Reduction

Childhood Recreational. Substantial increases in blood lead levels are predicted for particular play activities in contaminated areas of the Basin. Blood lead increments to existing baseline conditions were developed for this report. For most activities, appropriate action levels will likely vary between the 25th and 95th percentile concentration levels for the specific media. However, determination of appropriate risk reduction action levels for soil and sediments must be made in conjunction with concurrent decreases in baseline, or residential, risk levels. These analyses are not possible until appropriate baseline levels are available.

Childhood Consumption of Local Foodstuff. Similarly, the significance of local produce and fish from the lateral lakes area depends on the relative baseline blood lead level. In this case, a determination of allowable dietary intake based on baseline blood lead levels will be required. These can be compared to incremental fish and local produce intake tables relating intake to media contaminant levels.

Adult Occupational. Tables 6-57 and 6-58 show estimated blood lead levels associated with potential soil and dust concentration levels in occupational activities. These results suggest that in order to maintain 95% of reproductive aged women's blood lead levels below 10 µg/dl, protective measures should be taken for typical workers when in contact with soils exceeding 2800 mg/kg to 4500 mg/kg lead. For those workers engaged in heavy contact with soils for extended periods of time, the corresponding level of concern is 500 mg/kg lead.

Adult Recreational. Tables 6-59a-b and 6-60a-b show similar results for upland park, land-based, and CUA recreational activities. These results suggest protective measures should be employed for adults engaging in intense soil-related recreational practices with soils exceeding 3700 mg/kg.

Adult Consumption of Local Foodstuff. Some local vegetable garden produce shows high lead content that could substantially increase total intake to levels of concern among pregnant women. Adult consumption of local fish adds minimally to total intake at typical fish fillet lead concentrations. However, at maximum concentrations and consumption rates, the increased intake could be of concern, although it is unlikely that the species of fish providing the samples would be consumed in large amounts.

Native American Subsistence Activities. Native American subsistence practices in the Lower Coeur d'Alene River would be ill-advised. Soil and sediment ingestion rates associated with residence in the floodplain and food harvest practices are extremely high. Near background level concentrations would be required to achieve acceptable intake rates for soils and sediments. Additionally, two critical elements of the native diet, fish and water potatoes, contain unsafe levels of lead when aboriginal consumption rates are applied. Lead levels in these food sources may also likely need to be in equilibrium with background soil and water conditions to assure acceptable intake rates. However, appropriate background lead levels for biological media are unknown other than water potatoes in an adjacent drainage that show below detection levels for lead.